DRAFT ENVIRONMENTAL IMPACT STATEMENT

ON

Colstrip - Broadview 230 KV Transmission Line

Montana Department of
Natural Resources & Conservation

Energy Planning Division

JULY 1974

ERRATA

Summary Attachment I

Peabody Mining Company should read Peabody Coal Company

Environmental Action should read Environmental Action, Inc.

Issac Walton League should read Izaak Walton League of America

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DRAFT:

ENVIRONMENTAL IMPACT STATEMENT ON THE PROPOSED MONTANA POWER COMPANY AND PUGET SOUND POWER & LIGHT COMPANY 230 KV TRANSMISSION LINE FROM COLSTRIP TO BROADVIEW, MONTANA FOR COLSTRIP UNITS 1 & 2 ELECTRICAL GENERATING PLANTS AT COLSTRIP, MONTANA

JUNE, 1974

Department of Natural Resources and Conservation
Gary J. Wicks, Director
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1. Introduction

1.1 Description of Application

The application for permission to construct a 230 KV double circuit transmission line from Colstrip to Broadview was filed with the Montana Department of Natural Resources and Conservation (DNRC) on June 29, 1973 by the Montana Power Company (MPC) and Puget Sound Power and Light Company (PSPLC). According to the application, the line would be used to transport the power produced by electrical generating Units 1 and 2 at Colstrip into the applicants' electrical grid systems. The proposed line would extend 110 miles from the switchyard at Colstrip (Section 27, T2N, R41E) to the proposed MPC substation near Broadview (Section 20, T3N, R27E). The applicants submitted one preferred route and three alternate routes which the line could follow. The locator map on the following page shows the area crossed by these proposed routes.

An amended application was formally filed with the DNRC on January 2, 1974 which separated the 230 KV line from the other associated facilities of Units 1 and 2, all of which had been jointly applied for in June, 1973.

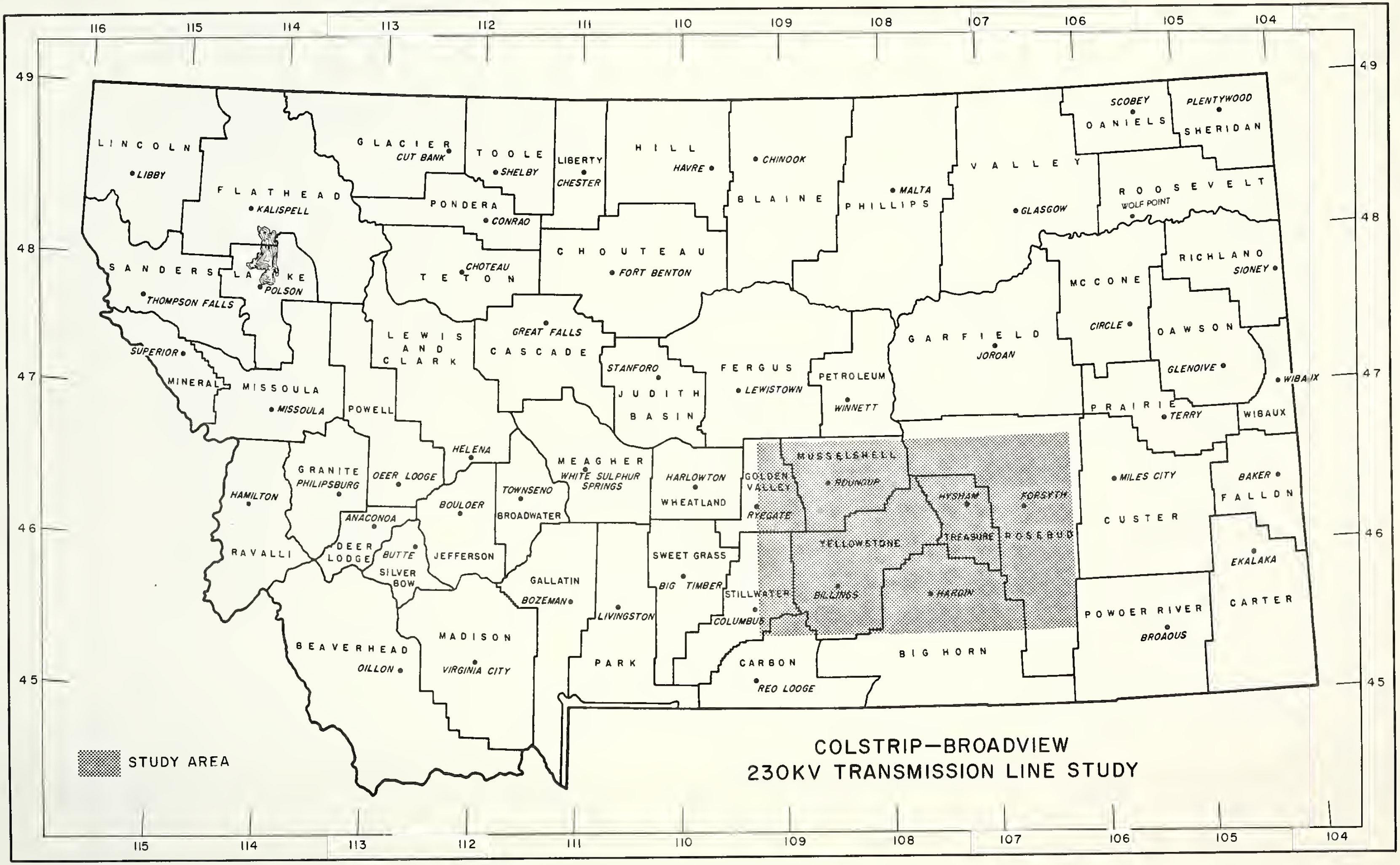
1.2 History

In August, 1972, MPC made application to the Montana Department of Health and Environmental Sciences (HES) for a permit to construct a 700 megawatt (MW) coal-fired electrical generating plant at Colstrip, Montana. Under the laws and regulations existing at the time, HES's Air Quality Bureau was to issue the permit if the applicant could meet all air quality standards and regulations. An EIS was written in compliance with the Montana Environmental Policy Act of 1971. This EIS was released in final form in March, 1973.

The Department of Health concluded that the permit to construct the facilities should be granted, and subsequently the Board of Health and Environmental Sciences concurred with the issuance of the permit. The permit was granted on April 23, 1973. Construction of the facility, though, had begun in late 1972.

The Montana Utility Siting Act became effective in March of 1973. Section 11(3) states that facilities or associated facilities under construction or in operation before January 1, 1973 are exempt from the Act. Units 1 and 2 of the generating complex were under construction before 1973, but the associated facilities (the water supply system and 230 KV line) for these units were not. Thus a certificate had to be obtained from the DNRC for the associated facilities in accordance with the Utility Siting Act.

As was noted in Section 1.1, the 230 KV line and the water supply system (which is composed of the water intake and pumping station on the Yellowstone River, the 26-inch pipeline from the river to the power plant, the surge pond, and a 115 KV transmission line to supply the pumping station with power) were separated by an amended application. The EIS on the water supply system was released by the DNRC on February 1, 1974. A public comment period and public hearing followed. The Board of the Department of Natural Resources and Conservation granted the permit to construct the water supply system on March 1, 1974.



COLSTRIP—BROADVIEW
230KV TRANSMISSION LINE STUDY

2. Methodology

2.1 Scope of Work

The evaluation of the proposed transmission line application has followed a distinct step by step process which is shown in the following diagram entitled "Transmission Line Study Methodology." The first step is an evaluation of need for the line. Need may be represented in terms of load growth (i.e., increased demand) within the applicants' electrical system, or need may take the form of a system reliability problem which requires that a new transmission line be built as security in case of power outages in existing lines. If need cannot be justified, this will later constitute a reason for denying the project in the final recommendation.

However, if need is established, the second step is to explore the possibility of utilizing or expanding the applicants' existing system to meet the need. A recommendation is made if this can be done.

Otherwise, as the third step in the process, a comparison is made of the relevant part of the applicants' proposal with alternative sources of electricity, alternative terminals where the energy may be received and alternative transmission technologies. This comparision is made to determine how need can be satisfied with the minimum amount of impact. In this case Units 1 and 2 at Colstrip have previously been approved as the energy source.

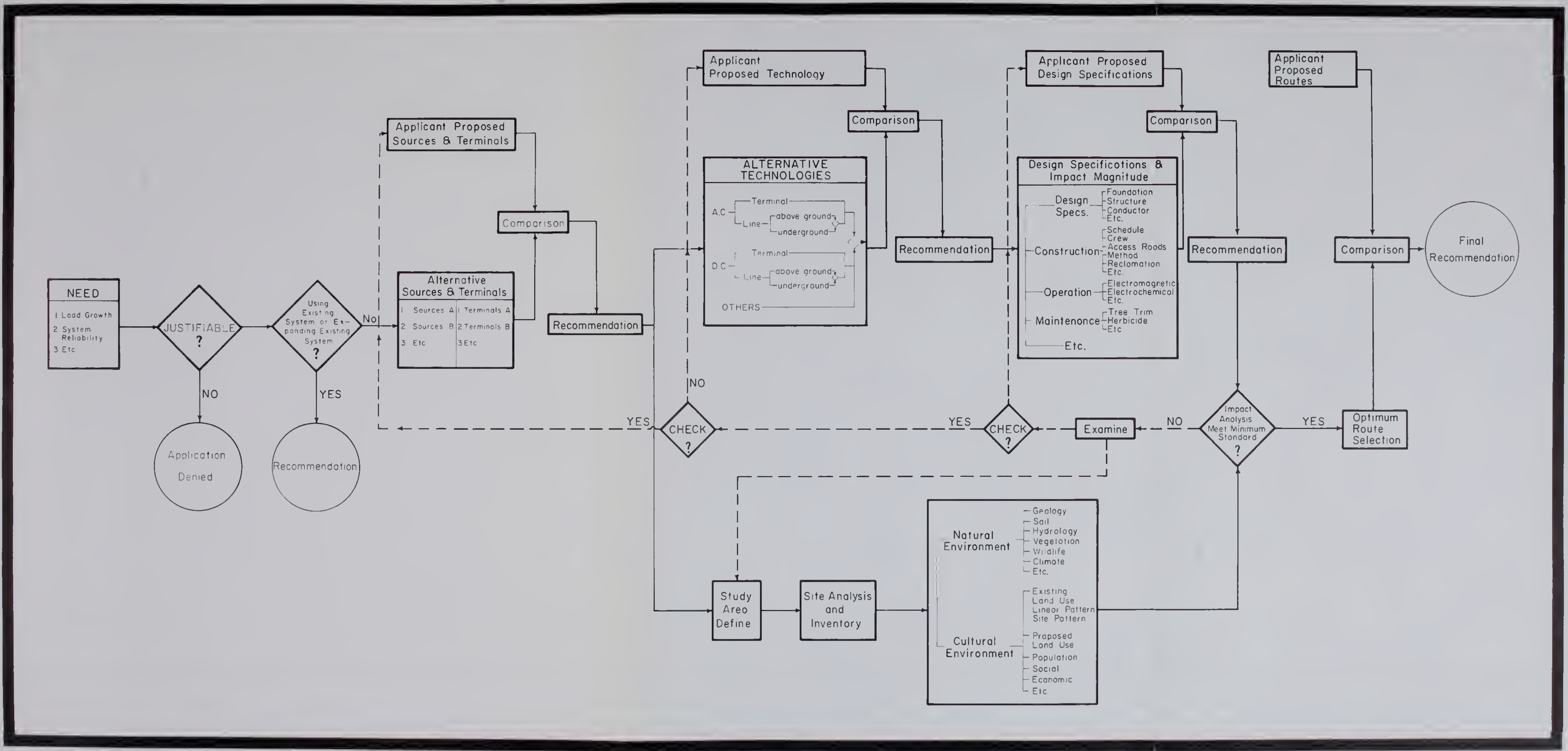
An evaluation of the design specifications and impact magnitude of the transmission line forms the fourth step in the application analysis. Foundation, conductor and structure designs are discussed in terms of the applicants' proposed facility. Construction of

access roads and tower sites is analyzed in terms of crew size, schedule, methods of construction and reclamation procedures. The operational characteristics of the proposed line (i.e., electrostatic and electrochemical effects, etc.) and maintenance activities are also examined. As a result of this overall analysis of the facility, specific recommendations may be made regarding any or all of the factors mentioned above.

Concurrently with the analysis of the proposed facility, an extensive cultural and natural resource inventory is made of an area large enough to encompass all feasible transmission line corridors (Chapter 6). Elements included in the natural environment are geology, hydrology, soil, vegetation, wildlife and climatology. The cultural environment encompasses land use -- linear and site patterns, population distribution, social factors, and economic aspects.

After the above elements have been inventoried, they are analyzed in terms of impacts which would be caused by construction, operation and maintenance of the proposed transmission line (Chapter 7). This analysis includes a literature survey of existing related impact studies and research and a discussion of impacts which may specifically occur within the study area. A check is made to insure that all potential impacts will meet minimum environmental protection standards. All the analyses are then collectively applied to select an optimum 2 mile-wide corridor for the transmission line which will cause the least total imapct. This procedure is discussed in Chapter 8.

The final step in the evaluation process is a comparison of the applicants' preferred corridor and the corridor selected by



TRANSMISSION LINE STUDY METHODOLOGY
Energy Planning Division
Department of Natural Resources & Conservation

the Department (Chapter 9). Then the input of public comment is incorporated before a final route recommendation is made for the proposed facility.

3. The Need

The most basic single function of the double circuit 230 KV line is to reliably deliver the output of Units 1 and 2 from Colstrip into the main transmission grids of the two applicant companies. Since Units 1 and 2 have previously been approved by the State, the proposed transmission line is needed to transmit the electricity generated from the units.

At the present time there are three transmission lines between Colstrip and Billings: a 230 KV line, a 100 KV line (100 KV from Colstrip to Hardin and 69 KV from Hardin to Billings), and a 69 KV line. The total design capacity of the three lines is approximately 400 MW. Unit 1 at Colstrip is scheduled to be on line in July, 1975. At that time one additional 230 KV line will be required for reliability. If this line is not built and a fault occurs on the existing 230 KV line, there may be damage to small lines or a shut down of the power plant. Therefore, another line is technically required to prevent this situation. When Unit 2 comes on line, the second 230 KV circuit will be used to carry power. The design capacity of the proposed Colstrip to Broadview line can vary from 350 MW to 450 MW for a single circuit.

According to computer analysis and the opinions of consultants hired by the Department, the double circuit 230 KV line is needed in the Billings area whether additional power plant Units 3 and 4 are built or not. Reasons given for this are as follows:

1) The power is to be delivered into the existing MPC 230 KV grid system. The Billings area is the logical place for

this connection from a system's engineering point of view.

2) The line is needed to provide protection to the generating units at Colstrip in terms of helping insure reliable transmission of their power.

3) The line is needed to provide switching capabilities from one line to another and to allow time for response in case of line faults in the system.

Load flow and system stability computer programs are currently being run to evaluate the pros and cons of the various transmission possibilities for the Colstrip power generation.

Need can be given many shades of meaning. Thus, definitions become very important. Need has traditionally been based on a projection of historic energy sales, peak demand trends, and the relation of these two to existing capacity within a given company's system.

The growth of electric energy consumption in this country has been both substantial and steady. There are at least two basic reasons for this growth rate: 1) electric energy is an extremely flexible form of energy and its end uses have multiplied rapidly; and 2) relative to other prices, the price of electricity has fallen substantially since World War II. While electricity's multiplying uses and flexibility may continue to be a potent force in expanding consumption, the long term decline in electricity prices is probably over. Increases have occurred since the late 1960's and they will continue in the future unless sizable technological advances are made.

In addition to the above causes of increased use of electricity, the role of advertising and promotional activities must be mentioned. The effects of advertising are hard to quantify, but they have presumably increased the use of electricity. It is difficult to justify "need" based on growth rates and subsequent demand that is influenced by the advertising of the utility companies. Past history may yield some indication of future demand, but there is a definite difference between "demand" and "need". If the difference between these two terms could be quantified, perhaps it would provide the major criterion for determining the need of proposed electrical facilities in the future.

It is the policy of the DNRC and the State to encourage energy conservation. If society's demand for energy continues at its present growth rate, the number of transmission lines and power plants required to meet the demand will be overwhelming. However, if an effort is made to conserve energy , many of these facilities may not be necessary in the future.

It should be noted that if permission is given to go from Colstrip to the Billings area with the double circuit 230 KV line, this, in no way, binds the State to approve the proposed 500 KV system to Hot Springs. The request to eventually convert the 230 KV line to a 500 KV system is contained within a completely separate application which is related to the proposed Colstrip Units 3 and 4 currently being studied by the Department. Therefore the Department does not consider the 230 KV line to be an incremental

part of the proposed Units 3 and 4 project. However, the impact of the proposed 230 KV line will be evaluated as the impact of a 500 KV line since this 230 KV line will be converted to 500 KV if Colstrip Units 3 and 4 are approved.

4. The Alternatives

4.1 Alternative Technologies

The goal of building adequate power generating and transmission capability to meet projected load growth at minimized natural, social and cultural costs may be considered an acceptable standard. The following sections discuss and compare various transmission alternatives in terms of this goal. A glossary is included at the end of this report which may be helpful in identifying terms used in this chapter and Chapter 5.

4.1.1 A.C. vs. D.C. Transmission

Power plants use alternating current (A.C.) generators and therefore produce power ready to be transported by A.C. transmission. Direct current (D.C.) generators, on the other hand, are obsolete in a power plant. Since the power plant produces A.C., this power must be converted to D.C. at the plant site if the power is to be transported by D.C. transmission. Then another conversion from D.C. back to A.C. must be made at the load center before the power can be used. In comparing A.C. and D.C. transmission lines one must consider technical efficiency and cost (including both environmental and economic costs).

Although transportation of electricity is the main function of transmission lines, the lines are utilized in many other ways. One major function of the transmission network is to provide backup capacity in case of generation and transmission outages. This will provide protection to service areas. Some lines will fulfill

coordinated operation of fossil and hydro plants and provide economic exchange of power and energy. Other lines serve the purpose of interchange of load diversity. Depending on the system, some lines can fulfill all of these requirements.

For a 110 mile line, such as the one proposed from Colstrip to Broadview, a D.C. system would be very costly because the terminal cost is very high. Also, a D.C. system would not be able to fulfill the previously mentioned functions of a transmission line while an A.C. system has all the aforementioned advantages and is less costly (see Fig. 1). Therefore, at this point an A.C. system may be more acceptable.

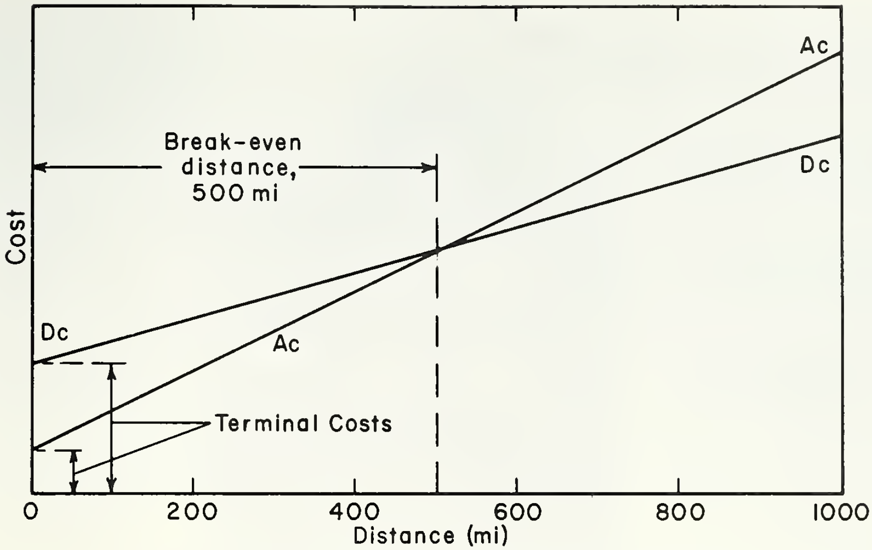
4.1.2 Overhead or Underground Transmission

Another decision which must be made is whether to use overhead (OHT) or underground transmission (UGT). The major areas of comparison are discussed below.

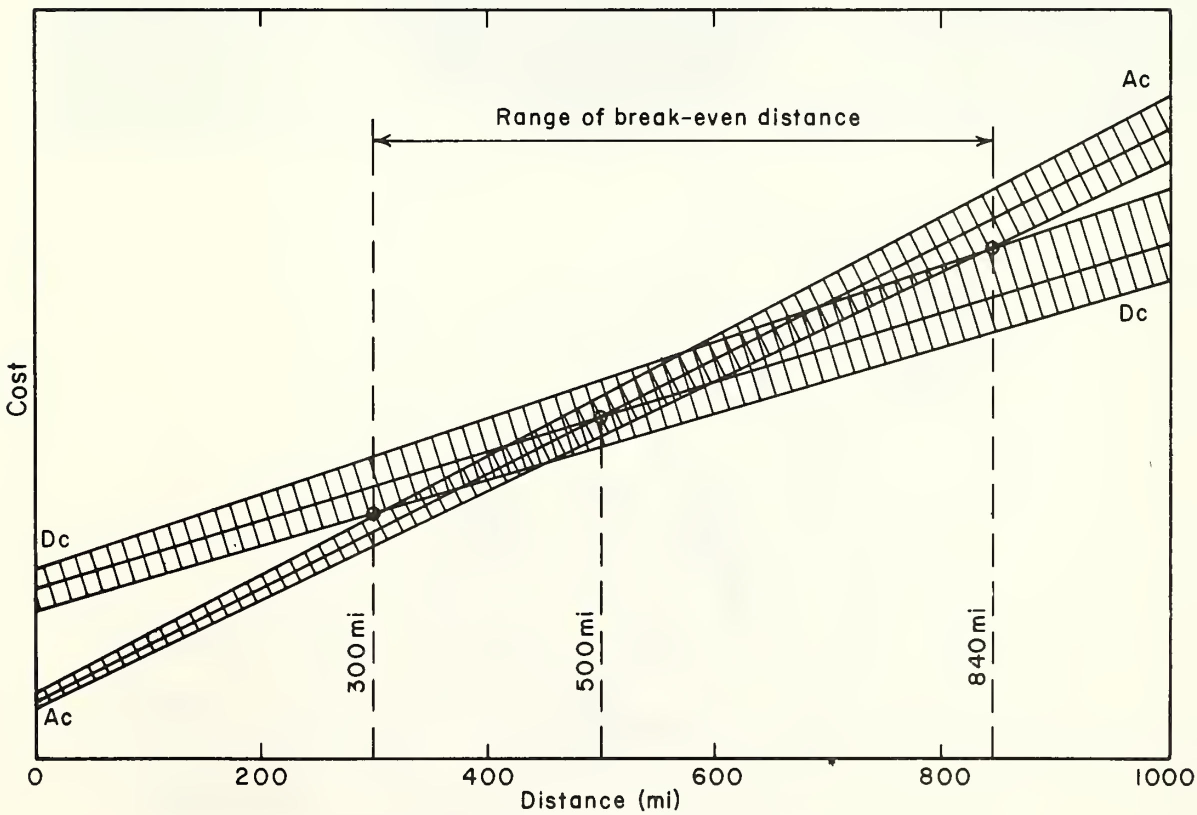
Transmission line conductors require insulation if current is passing through them. In OHT air works as the insulator with 10-25' of spacing or more between conductors. Insulation for UGT, on the other hand, creates a chain reaction of problems. UGT requires insulation made of paper, rubber, plastic, polyester fabrics or other material, which creates a problem of heat dissipation. As a result, cooling agents such as oil or inert gas are required for higher voltages. A second problem is that the insulating material lacks mechanical strength of its own. Therefore, it is customary to insert a metallic sheet (known as a shield or

sheath) between UGT insulation to increase the mechanical strength of the cable (see Fig. 2). However, this creates a third problem. At high voltages the distance from the outer surface of the cable to the shield or sheath (which is at earth potential or near zero voltage) is small (approximately one inch). This small distance is responsible for continuous flow of so-called "charging current" between the conductor and sheath which serves no useful purpose. This current's magnitude varies inversely with the thickness of the insulation and varies directly with the length of the cable and the magnitude of voltage. It has been calculated that at 345 KV voltage, practically all the current carrying capacity of the cable would be utilized by the charging current in a distance of about 26 miles. (For a 230 KV line the distance may be about 40 miles and for a 500 KV line it may be about 16 miles.) Techniques are available to overcome this effect by use of "compensation" equipment, but this is very expensive. Charging currents are also present in overhead lines, but the magnitude is very small due to the greater spacing between the conductors and the distance from the conductors to the ground.

A trench must be dug in order to place a UGT line under the ground. The impact this will have upon the natural environment and the subsequent loss of soil moisture content due to heat from the conductors, must be considered in comparison with the much less extensive tower foundation digging required for OHT lines.

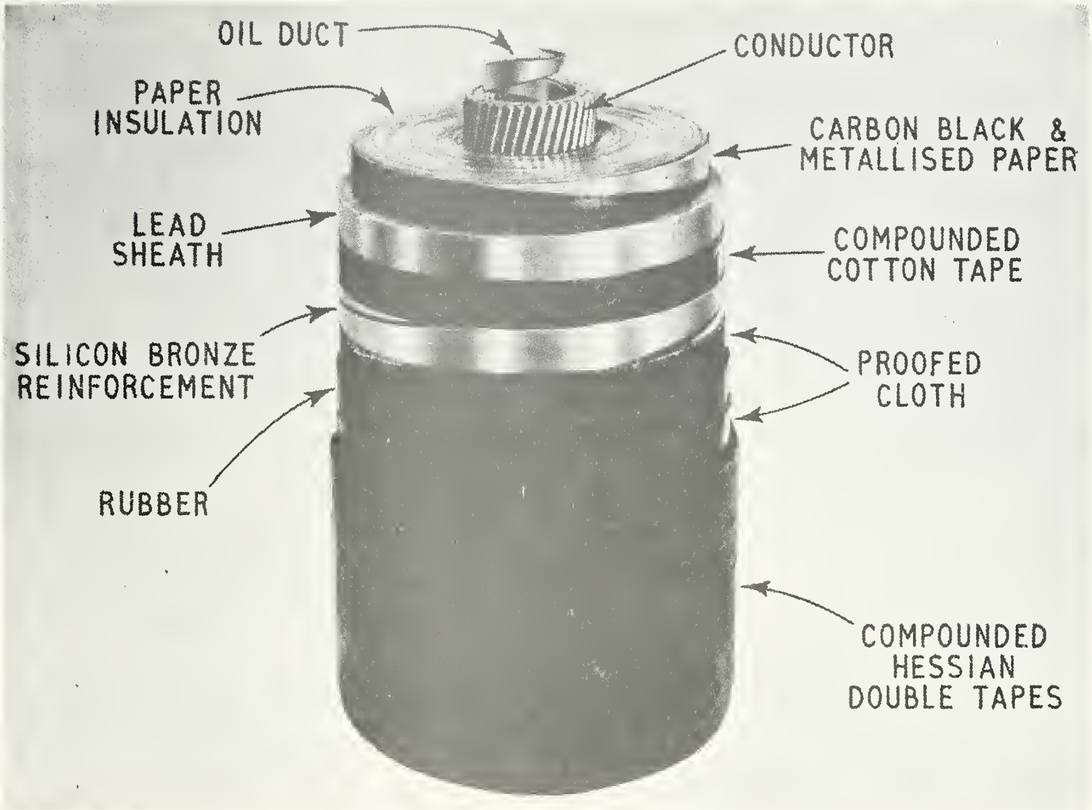


COMPARATIVE COSTS OF AC AND DC
OVERHEAD LINES VERSUS DISTANCE

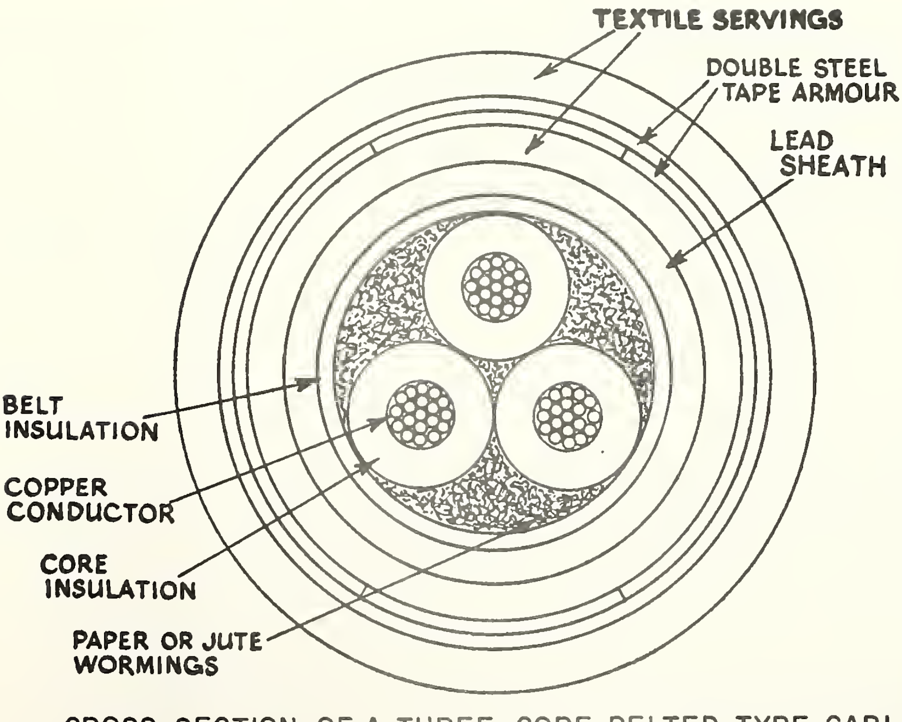


EFFECT OF VARIATION OF COSTS
ON BREAK-EVEN DISTANCE

Figure I (Kimbark, 1973)



SINGLE PHASE CABLE



CROSS-SECTION OF A THREE-CORE BELTED TYPE CABLE

Figure 2 (Barnes, 1966)

Costly cable materials, line compensation equipment, cable terminal material, and the trenching operation all make underground lines more costly than overhead lines. UGT lines are also expensive to repair in terms of both the time and techniques involved. The following two cost figures for these two types of transmission are taken from the report submitted to the Federal Power Commission in April, 1966 by the Commission's Advisory Committee on Underground Transmission.

Overhead Transmission Line

Voltage	Conductor Type	Nominal Summer Thermal Rating	No. of Circuits	Average Cost per Mile
230 KV	1431-ACSR	980 MVA	2 (on steel poles)	$128,000

Underground Transmission Line

Voltage	Conductor	Pipe Size	Nominal Summer Thermal Rating	No. of Circuits	Average Cost per Mile
230 KV	2000 MCM	$10\frac{3}{4}$"	638 MVA	2 (same trench)	$908,000

These cost figures are, at best, approximations because terrain and weather conditions are major factors and these will obviously vary with location.

The obvious major advantage of UGT is that it creates no aesthetic (visual) impact. Also, line outages due to wind, ice, snow and weather can be eliminated. The choice, then, is whether or not to spend seven times the financial cost for these advantages. This kind of decision should be made at a very early stage of the project, because engineering studies and ordering of materials may require two years or more, depending on market availability. Overwhelming economic cost is a major reason why UGT is not feasible at this time. Research is not progressing rapidly on methods to reduce cost and overcome the other problems mentioned previously. It should also be noted that the environmental impacts of UGT are not fully known. Furthermore, in this particular case the time element may not permit UGT because Colstrip Units 1 and 2 are already under construction.

4.1.3 Alternative Structure Design

Detailed engineering studies are required for selection of transmission line towers. The factors affecting the design of towers are (a) system loading which will cover ice and wind loading, (b) properties of conductors and insulators, (c) vertical, transverse and longitudinal loads into the plane in which they act, and (d) distribution of torsional moments in the tower caused by broken conductors or a pull imposed during the stringing operation. "Stress Analysis Programs" are developed to cover all these factors. Input to these programs consists of tower geometry, topology, member properties of tower elements, and loads. The programs generate a mathematical model of the tower in terms of a

stiffness matrix. The model is then subjected to the various loading conditions. The output consists of the geometry of the deflected tower, the axial force in each member, and the specified reactions for each loading condition. In the whole line, 80% of the towers used are selected by the above methods and 20% are special towers used at river crossings and special locations where extra strength is required.

The two major types of structures are steel towers and wood poles. The height of steel towers suitable for the proposed line varies from 102' to 146' with tower foundations 10' to 20' deep. An average of 4 to 6 steel towers is required per mile with a right-of-way of 150'. A more detailed discussion of steel towers is presented in section 5.2.1.1.

Wood pole structures of the "H" frame design could be used for a line such as the one proposed. Wood poles would require a 100' right-of-way with approximately 7 structures per mile and a 32' mid-span clearance. The standard "H" frame structure is 80' to 90' high and has a foundation 9' to 13' deep. Diesel trucks and trailers with a maximum weight of 30 tons are used to distribute the poles, and other trucks and caterpillars are used to erect the structures and string the conductors. At angles and river crossings, 3 poles with guy wires might be required. These types of structures have one heavy conductor (1272 MCM ACSR, 1.382" diameter) per phase. Use of a single conductor per phase may result in more corona losses and a high probability of radio-TV interference.

In comparing steel towers and wooden poles, it appears that steel towers may be more practical. The proposed 230 KV line would require two separate wood pole single circuit lines in separate rights-of-way, because a single row of wood pole structures cannot accommodate a 230 KV double circuit line. Thus, wood poles would use up to 200' of right-of-way. Also, there would be more wood pole structures (14) per mile than would be necessary with steel towers.

The aesthetics of structure design are important in minimizing visual impact and blending the structure with the surrounding environment. Visual impact cannot be rigidly defined, but wooden structures are generally considered to blend in with the environment better than steel poles. However, the factors mentioned in the above paragraph seem to favor steel towers in all aspects except visual.

The applicants have provided very few alternative structure designs relating to aesthetic values. This apparently reflects lesser emphasis placed on aesthetic considerations.

5. Description of Proposed Facility

MPC has proposed in its application to construct 110 miles of electric transmission line. The 230 KV transmission line from Colstrip to Broadview will initially be conductored and insulated to operate as a double circuit 230 KV line, but will be engineered and constructed to eventually support a 500 KV line.

The conversion to a 500 KV line will be made if MPC is given permission to do so in a subsequent application. This conversion would increase the power carrying capacity of the line by almost four times (i.e., conductors which are capable of transfering 370 MW at 230 KV can transfer 1500 MW at 500 KV).

5.1 Proposed Alternative Corridors and Terminal Sites

Montana Power Company has proposed three alternative corridors (Routes B, C and D) as well as one preferred corridor, Route A. These routes are shown on the map overlay located in the back envelope of this report. The terminal sites will be the end points of the corridors because the applicants have not applied for construction of a substation at specific sites.

5.2 Proposed Design Specifications

5.2.1 Transmission Line

5.2.1.1 Structure

The applicants have proposed two kinds of steel structures which are shown in Figures 3 and 4; one is self-supported and the other is a guyed delta. For the major portion of the transmission

route the applicants have proposed to use guyed delta towers supported by four guy cables. The tower height will vary from 102' to 146' and the ground distance between the guy cables and the tower will vary from 60-70'. The tower foundations vary from 10' to 20' deep depending upon geological conditions and terrain. Minimum mid-span clearance will be 37'.

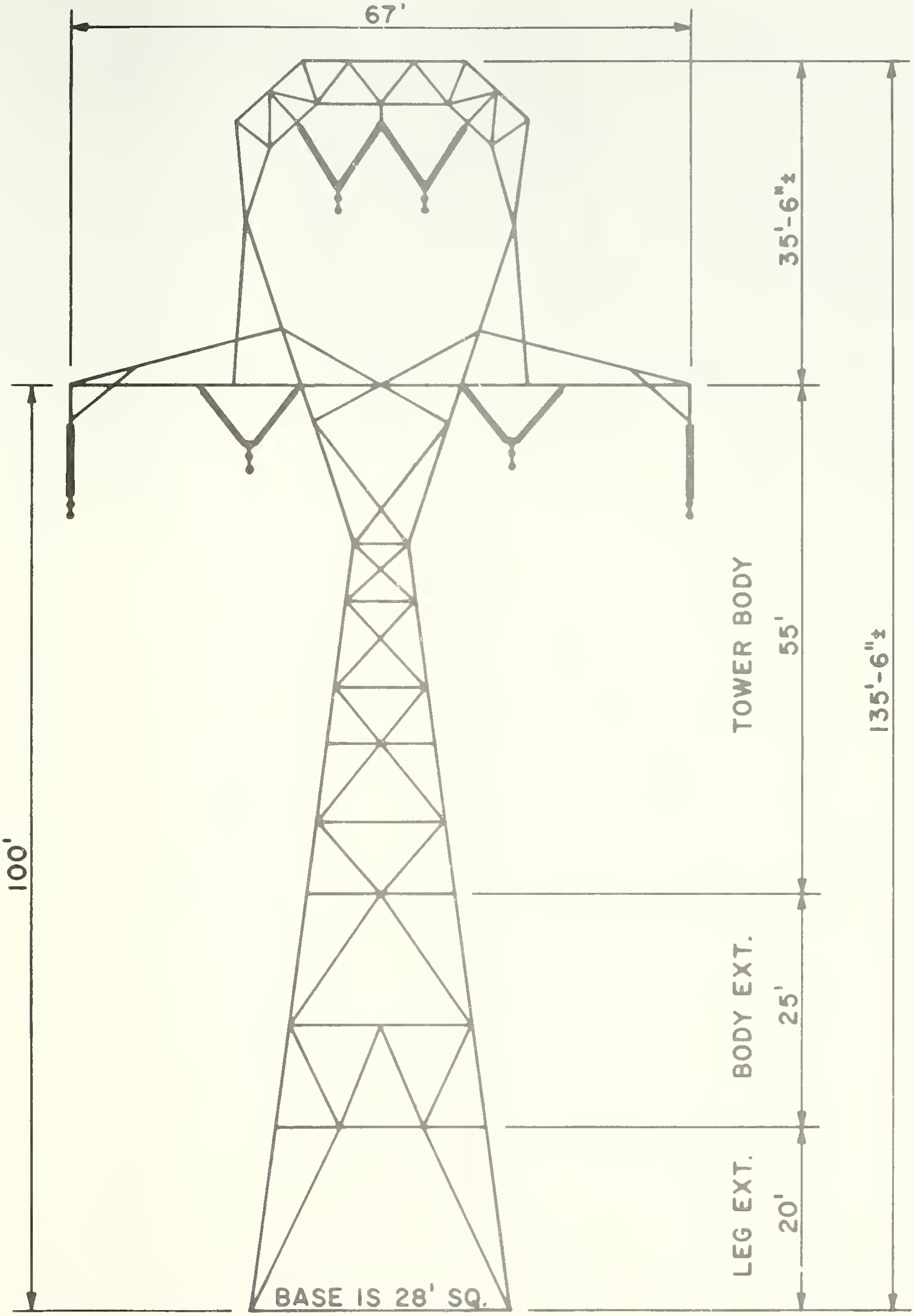
The self-supported towers are designed for 28' by 28' base dimensions with 10' to 20' deep foundations. These towers will be used at river crossings, angles and at spots where more strength will be required to resist gusting wind and heavy snow.

The applicant has proposed to use 4 to 6 towers per mile. The right-of-way width is 150' for single towers and 300' for two towers placed side by side.

Both of the structures described above are designed to support 4 conductors per phase for a 500 KV circuit (12 conductors total for 3 phases) or 2 conductors per phase for a 230 KV circuit (6 conductors total per circuit) with two circuits per tower (i.e., a total of 12 conductors on one tower). The applicants have mentioned that they will intially arrange the 12 conductors in the form of a 230 KV two circuit line. Each circuit will have three phases and in each phase there will be two conductors. This arrangement can be converted to a 500 KV single circuit line (see Fig. 5) if authorized in the future.

5.2.1.2 Conductors

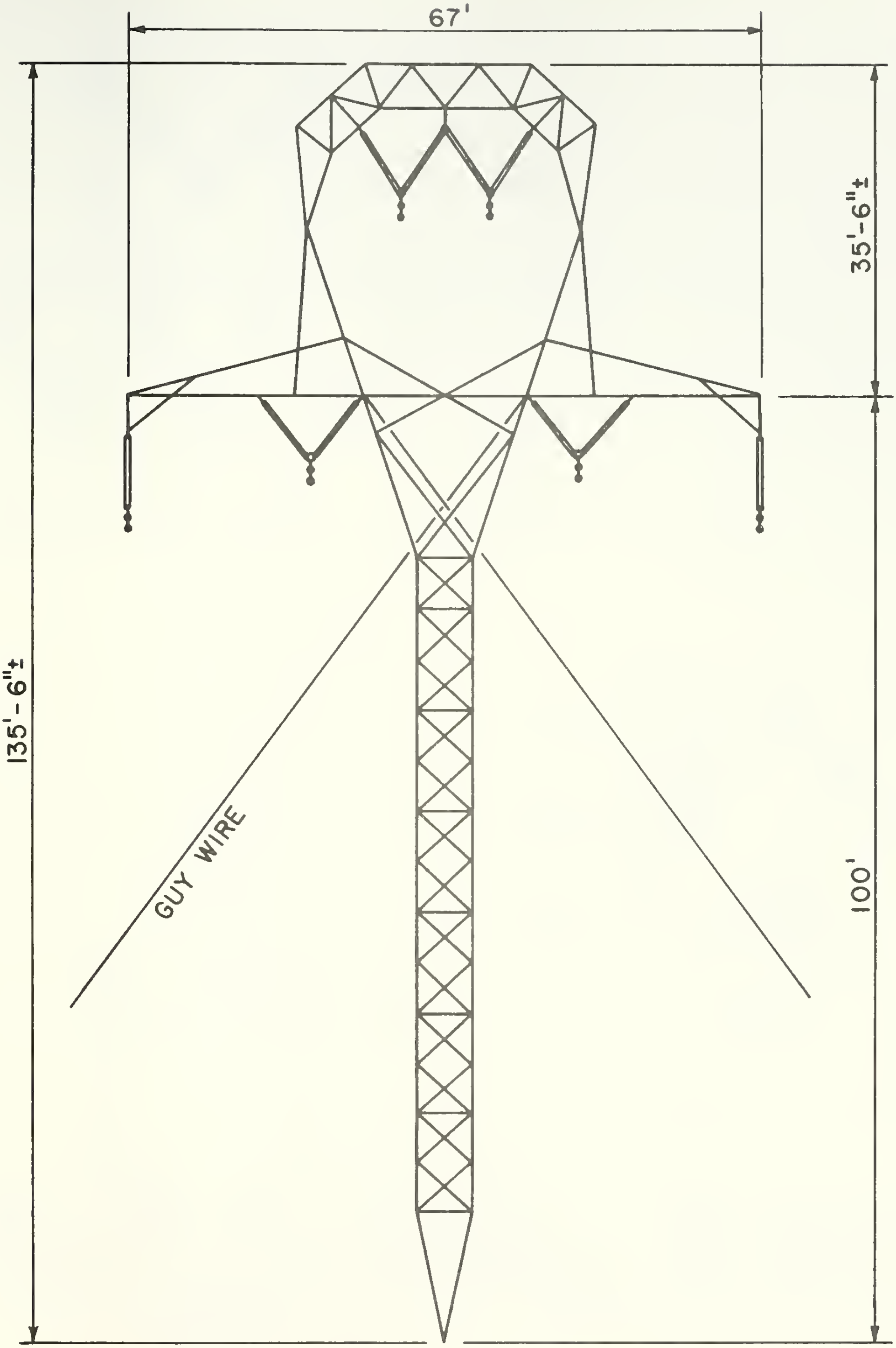
There will be 12 conductors irrespective of whether 230 KV circuits or a 500 KV circuit is used. The only thing affected



230 KV DOUBLE CIRCUIT TOWER – SELF SUPPORTED
DELTA CONFIGURATION

(Westinghouse, 1973)

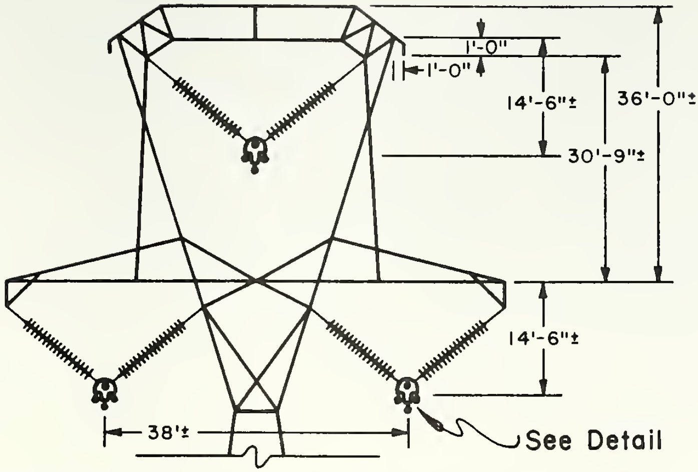
Figure 3



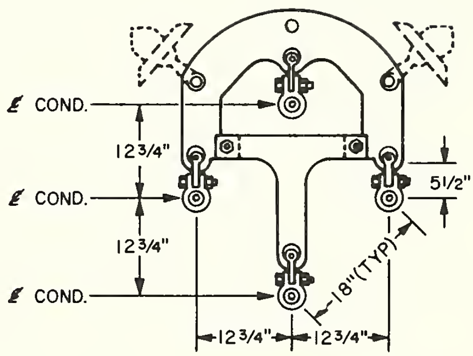
230 KV DOUBLE CIRCUIT TOWER – GUYED
DELTA CONFIGURATION

(Westinghouse, 1973)

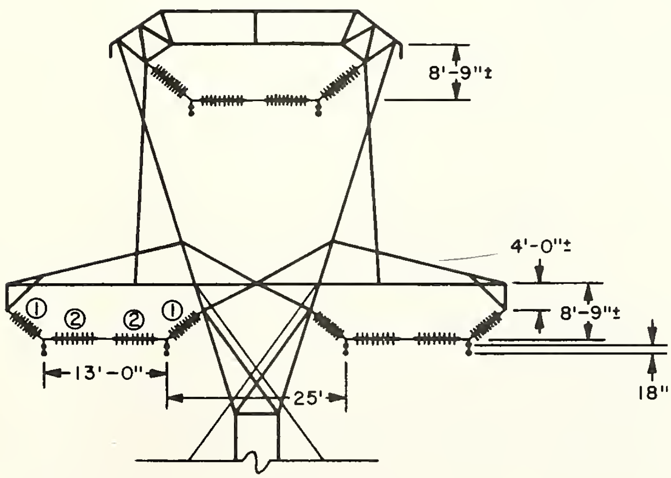
Figure 4



500 KV SINGLE CIRCUIT ARRANGEMENT



DETAIL



① 14 Insulator rings
② 11 Insulator rings

230 KV DOUBLE CIRCUIT ARRANGEMENT
Same tower top as 500 KV tower

Figure 5 (Westinghouse, 1973)

is the arrangement of the conductors (see Fig. 5). The technical information for the conductors was given by the applicant as follows:

Diameter 1.019" (636 MCM ACSR)

R = .0803Ω/phase-mile

X_L = .5673Ω/phase-mile

X_C = .1332 MΩ/mile

There are three kinds of losses involved in transmission lines:

(1) Resistive losses: 15.5 MW/cct

(2) Inductive losses: 110 MVAR/cct less 45 MVAR reactive

(3) Corona losses in foul weather: 2-5 KW/mile for 230 KV

Phase spacing (see Fig. 5) will be 13' between double circuit conductors with 25' between the two lower phases. The delta configurations which are used have a vertical distance between phases of about 32'. If and when the line is converted to 500 KV, the phase spacing will be approximately 38'.

Two static wires are to be used. The insulators are 10" bell-diameter and 5-$\frac{3}{4}$" high. A double circuit 230 KV line requires 14-11-11-14 insulators and a single circuit 500 KV line reqiures 25-25 insulators (see Fig. 5).

5.3 Proposed Construction Methods

5.3.1 Proposed Access Roads

The applicant contends that specific access roads cannot be located until a center line is established for the transmission corridor. However, the following guidelines for construction have

been established by the applicant for access roads (MPC, unpub.). Where permitted, access roads and service roads will be maintained with grass cover, water bars, and the proper slope in order to prevent soil erosion. Existing roads will be marked for use as access roads wherever feasible. New roads shall follow approved routes and shall be constructed with the minimum possible clearing and soil disturbance. The road width shall be determined by need, such as equipment size, and shall be no wider than necessary. During construction , unauthorized cross-country travel and creation of roads beyond those approved will be prohibited.

The limits of where construction equipment and vehicles can and cannot go will be clearly marked at each new site before equipment is brought in. Construction foremen and personnel shall be well versed in recognizing these markers and shall understand the restrictions on equipment movement that is involved. Other guidelines which pertain to access roads will be mentioned in section 5.3.2.

5.3.2 Proposed Construction

5.3.2.1 Clearing Right-of-Way

Clearing will consist of crushing or clipping brush or other low-growing vegetation rather than uprooting it. Clearing of trees will be limited to those which will interfere with the line. They will be cut to within 12 inches of the ground, but stumps will not be removed unless they interfere with foundation structures. Between towers where no traffic is required, vegetation shall be selectively cut to remove any interference with the

conductors. Wherever appropriate, selective clearing will be done to produce curved or wavy boundaries in an attempt to reduce a straight line of visual impact. There shall be no removal of grasses or shrubs except as required for the pulling line. The greatest allowable height of any vegetation is 17 feet.

Maintenance of the right-of-way will consist of periodic cut-backs and removal of larger trees. No herbicides will be used. Stripping the earth of sod or duff layer will occur only in rocky areas or slopes where cuts and fills are necessary for vehicle movement.

5.3.2.2 Erection of Structures

The physical erection of structures will be conducted by the contractor awarded the job. Staging areas or locations where transmission line parts will be stored and sub-assembled will most likely be established every thirty (30) to thirty-five (35) miles. It is desirable to locate these areas adjacent to both railroads and existing roadways. The staging areas will be approximately 5 to 10 acres each in size. Although longer separation distances will result in larger land areas for the staging sites, the areas will be kept to the smallest practical size. They will be maintained and after completion of construction, vacated according to the applicants guidelines for minimizing environmental effects (see Section 3.6.1, Westinghouse, 1973).

The actual erection of the towers will follow the tower site preparation which includes digging of foundations and various anchors for the guys. Materials will be brought from the nearest

staging area to the tower site. Some of the sections may be subassembled while at the staging area. For the most part, however, assembly will be done at the tower site a section at a time. Then, depending on the size of the crane to be used in assembly, the sections will be hoisted into position and fastened to the tower. The best estimate of the applicant is that two, sixty (60) ton hydro-cranes will be used during construction; however, it is probable that only one crane will be used at a given tower site.

This description is quite general because the applicant has not yet selected the contractor to build the transmission line. Therefore, a specific construction procedure has not been established. If the transmission line is approved, the Department will make the condition that the applicant shall obtain prior approval in regard to the construction procedures.

5.3.2.3 Stringing of Conductors

The last step of the tower erection and the first step of stringing the conductors is the installation of suspension insulator strings. These insulators are hoisted up the towers and fastened to the structural steel in the appropriate tower windows. Stringing sheaves are then attached temporarily to the insulator strings and the conductors are pulled through the sheaves. Pulling is done by a tractor or caterpiller at the far end of the line section. Various "grips" are used to attach the cable to the end of the conductor. The cable can then be fastened to the tractor and used to pull the conductor over the stringing sheaves.

When a line section is strung, the proper tension is achieved by using take-up pullers. Separate engines drive the take-up reels. Linemen at various positions along the line, using two-way radios to communicate, coordinate the pulling and tensioning to the appropriate values. Once the conductor is in place with the proper amount of tension, work platforms are raised for the linemen who apply the finishing touches to the conductors. These linemen remove the stringing sheaves, attach corona shields, clamp the conductors to the suspension insulator strings, install preformed armor rods to the conductors, and if necessary, apply vibration dampers. The final step is the installation of spacers which maintain fixed separation among grouped conductors.

5.3.3 Proposed Construction Schedule and Crew Size

Information concerning the construction schedule for the proposed 230 KV double circuit line was prepared by the applicant in the form of a critical path diagram on April 4, 1974. Based on this critical path diagram, the over-all time necessary to complete the transmission line while working six (6) day work weeks would be almost twenty (20) months after obtaining a state certificate to construct. However, this time schedule could actually range from 18-24 months (the 15 month schedule would depend on special arrangements and whether all of the conditions of the certificate are met).

1. Obtain state certificate
2. Acquire remainder of right-of-way
3. Obtain state approval on construction procedures

4. Award contract
5. Contractor mobilization
6. Build gates, roads, clear right-of-way
7. Install foundations
8. Install anchors
9. Assemble towers
10. Erect towers
11. Install insulators
12. Install conductor
13. Cleanup

Most of the steps have several phases which may be occurring concurrently with other steps. Steps not mentioned above are right-of-way previously acquired and material delivery steps which will affect the schedule but are not construction per se. Again, it is impossible to give specific dates for each step until a starting date is known.

The crew size will be a function of the contractor which is finally awarded the job. However, the applicants have estimated an average of 60 to 70 men for a period of fifteen months (MPC, unpub.) The fifteen month period has been lengthened to about 20 months by the critical path diagram.

5.3.4 Proposed Reclamation Methods

The reclamation methods proposed by the applicant are best described as "post-construction cleanup and road closure" (Section 3.6.1.2.12, Westinghouse, 1973).

1. All signs of temporary construction facilities such as haul roads, work areas, structures, foundations of temporary structures, stockpiles of excess or waste materials, or any other vestiges of construction shall be restored as is practical.

2. Filling and plowing of roadways will be required where appropriate to restore the area to near natural conditions that will permit the growth of vegetation thereon and discourage future traffic.

3. Any landscape feature scarred or damaged by equipment or operations shall be restored as nearly as possible to its original condition.

4. In areas where no cut or fill was made, closure of roads shall be completed by barriers of berms, rocks, plants or whatever, and signs after scarifying, water-barring and revegetation are complete.

5. Replacement of earth adjacent to access roads crossing water shall be at slopes less than the normal angle of repose for the soil type involved.

6. Disturbance of drainage bottoms shall be minimal, and all bottoms shall be restored to their preconstruction gradient and width to prevent accelerated gully erosion.

7. Cross drains shall be added at an angle and frequency appropriate to road grades.

8. Drainage systems which have been interrupted shall be restored for all cleared center lines.

5.4 Proposed Operational Characteristics

After a transmission line is energized, especially at EHV (extra high voltage -- above 345 KV) some new problems such as corona discharge (see Section 5.4.3) and other operational characteristics emerge. The phenomena which cause the most concern to the public are audible noise, radio and TV interference (RI and TVI), electrostatic effects, and electrochemical

reactions. These four concerns depend very much on voltage level, weather conditions, engineering design specifications, and other factors which may affect them individually.

5.4.1 Audible Noise

This is an engineering design problem which can be magnified by foul weather conditions. In the past, properly designed transmission lines below the 345 KV level have exhibited unnoticeable audible noise levels. However, lines below the 345 KV level which were not properly designed for noise control have exhibited quite high audible noise levels. The proposed 230 KV line has two conductors per phase. This design is technically sound, and thus audible noise may not be a problem. However, a 500 KV line may be well designed and still not eliminate all audible noise problems.

5.4.2 Radio and TV Interference

When a radio or television set is turned on, the reception depends upon the strength of the station's signal as it comes through the antenna. Signal strength is expressed in units of decibels (db) and depends on the broadcasting capacity of the station and terrain of the area. Another important factor is background noise level. If noise is also measured in 'db' then the "signal to noise ratio" (SNR) is the factor which will determine whether radio and television reception is good or bad. This ratio is obtained as follows: For example, if signal strength is 65 db and noise level is 35 db, then SNR will be 30 db (65 db - 35 db = 30 db). The quality of reception depends on this ratio. The six

different grades of SNR are listed below (Priest, 1971):

Grade	Signal to Noise Ratio (SNR)	Reception
A	32 db or more	Excellent
B	27 db to 31 db	Good
C	22 db to 26 db	Fairly satisfactory
D	16 db to 21 db	Speech understandable
E	11 db to 15 db	Speech understandable with severe concentration
F	below 10 db	Unintelligible

5.4.3 Electrochemical and Electrostatic Effects

Air works as an insulating agent around the conductors on overhead transmission lines. As voltage levels go higher and higher, the changes in humidity and weather affect the strength of the air's insulating properties and deionization in the air begins. This complicated phenomena is expressed in "Critical Voltage Gradient" (CVG) which is measured in units of peak kilovolts per centimeter (KVp/cm). When CVG approaches 22-24 units (22 KVp/cm to 24 KVp/cm), air can no longer work as insulating material for bare conductors and many different kinds of reactions begin to occur.

The CVG for a 230 KV transmission line will be around 11 to 13 KVp/cm which is lower than the threshold value of 22-24 KVp/cm. Therefore, electrostatic and electrochemical effects may not be significant at the 230 KV level. However, studies are presently being made to determine whether any particular cases of these effects are experienced under existing 230 KV lines. Other studies are currently under way to examine the effects of 500 KV lines.

6. Site Description

6.1 Definition of Study Area

The study area is defined as the geographic area which is large enough to accommodate all possible and practical corridors from Colstrip to the Billings - Broadview area. The boundaries of the study area are shown on the map "Colstrip - Broadview 230 KV Line Study Area" located in Chapter 1.

It is crucial to develop a thorough list of natural and cultural environmental elements (or parameters), sub elements and sub-sub elements as they will be either affected by or will have constraints upon construction, operation and maintenance of a transmission line. During the process of generating an environmental element list, one must remember that these elements have to have a relationship with transmission corridor selection. Otherwise, the elements can only be used as background information. Success in generating a thorough and correct list of elements will ensure the success of transmission corridor selection and vice versa.

6.2 Natural Environment

6.2.1 Geology

6.2.1.1 Physiography

The study area lies within the unglaciated portion of the Missouri Plateau of the Great Plains Province as defined by Fenneman (1931). Other authors refer to the structural and sedimentary basins of the study area as the Powder River Basin. Kepferle (1954) describes Rosebud County as being part of the Fort Union-Powder River region. The area including much of eastern

Montana and parts of Wyoming, South Dakota, North Dakota and Canada where the Fort Union formation occurs is known as the Fort Union region (Ayler, 1969). A structural low which occurs between the Black Hills uplift and the Bighorn Mountains is known as the Powder River Basin. This feature is structural and is different from the drainage basin of the Powder River. Except for some small areas, the topography of the area is developed upon nearly horizontal sedimentary rocks.

Three major streams pass through and drain the area -- the Yellowstone, Bighorn and Musselshell Rivers. A number of smaller streams flow into the Yellowstone from the south, including the Clarks' Fork of the Yellowstone, Pryor Creek, Sarpy Creek, Armell's Creek, and Rosebud Creek. The Tongue River, which passes through the southeast corner of the area, is also a tributary of the Yellowstone. The Little Bighorn River empties into the Bighorn at Hardin in the south central part of the study area. The Musselshell River flows into Fort Peck Reservoir on the Missouri about 40 miles north of the study area.

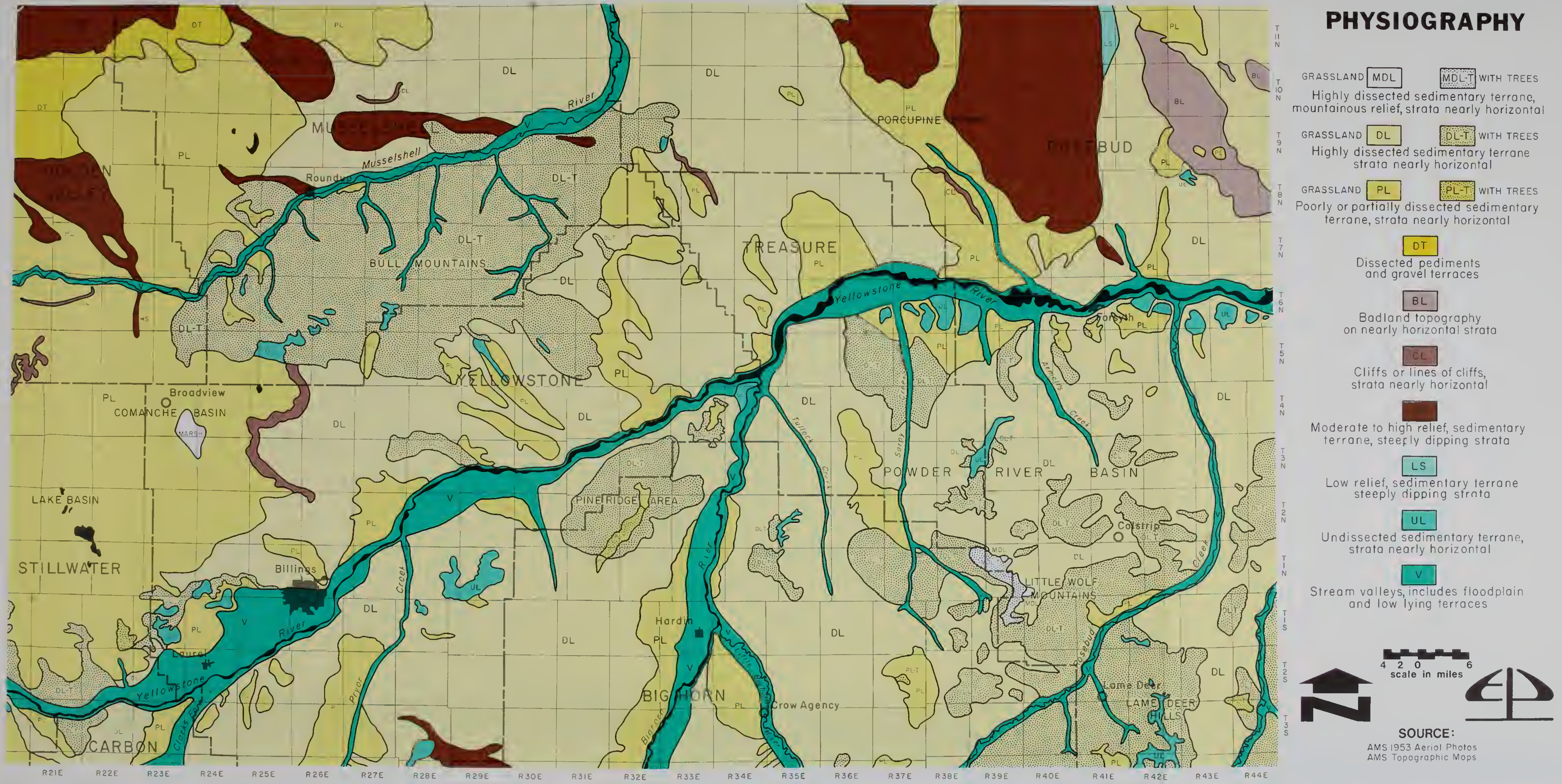
A number of notable upland areas exist between the major streams. A small part of the Big Snowy and Little Snowy Mountains projects into the northwest corner of the study area. The much lower Bull Mountains lie mostly south of the Musselshell River in the western half of the area. Smaller upland areas such as the Pine Ridge area, the Little Wolf Mountians, and the Lame Deer Hills lie south of the Yellowstone River.

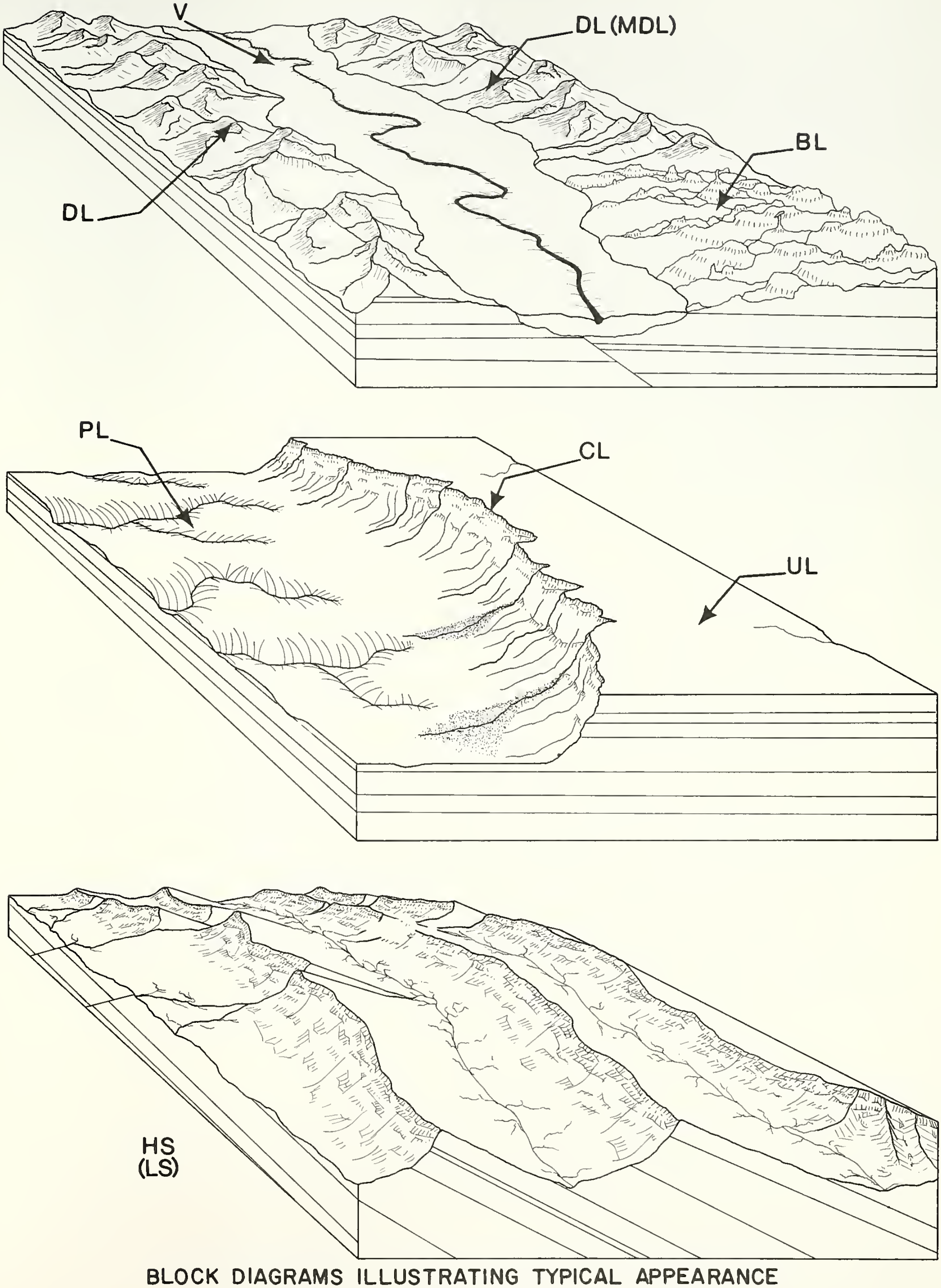
Except for the area in the Snowy Mountains where elevations within the study area are as high as 8,000', elevations range from less than 2,500' in the Yellowstone Valley on the eastern edge of the area to 4,700' in the Bull Mountains and 4,800' in the Little Wolf Mountains.

Most of the study area is underlain by nearly flat lying sedimentary rocks. The varying resistance to erosion of the different strata and the kinds of erosional processes which predominate in this area have produced a landscape which consists mostly of dissected uplands.

Map Unit Descriptions

The study area is portrayed on the physiographic map as a number of characteristic landform associations. Within each of these units, the landform entities create a similar type of topography. Although only high altitude aerial photographs (scale 1:60,000) and topographic maps (scale 1:250,000, Army Map Service) were used in preparing this map, correlation with maps portraying soils information, population density and land use is possible. This correlation should not be surprising, in that landforms and their distribution strongly influence the patterns of these other features. For instance, an area delineated as a highly dissected upland would generally lie some distance from a source of surface water and would have thin soils on steep slopes. The agricultural and population patterns in this area would be quite different from a river valley where thicker soil, very gentle slopes, and good


PHYSIOGRAPHY
GRASSLAND MDL
MDL-T WITH TREES
Highly dissected sedimentary terrane, mountainous relief, strata nearly horizontal
GRASSLAND DL
DL-T WITH TREES
Highly dissected sedimentary terrane strata nearly horizontal
GRASSLAND PL
PL-T WITH TREES
Poorly or partially dissected sedimentary terrane, strata nearly horizontal
DT
Dissected pediments and gravel terraces
BL
Badland topography on nearly horizontal strata
CL
Cliffs or lines of cliffs, strata nearly horizontal
Moderate to high relief, sedimentary terrane, steeply dipping strata
LS
Low relief, sedimentary terrane steeply dipping strata
UL
Undissected sedimentary terrane, strata nearly horizontal
V
Stream valleys, includes floodplain and low lying terraces
4 2 0 6
scale in miles
SOURCE:
AMS 1953 Aerial Photos
AMS Topographic Maps
PORCUPINE
Musselshell
River
Roundup
BULL MOUNTAINS
TREASURE
Yellowstone
River
YELLOWSTONE
Broadview
COMANCHE BASIN
MARSH
LAKE BASIN
STILLWATER
Billings
Laurel
CARBON
PINE RIDGE AREA
Hardin
BIG HORN
Crow Agency
POWDER RIVER BASIN
Colstrip
LITTLE WOLF MOUNTAINS
Lame Deer
LAME DEER HILLS
Forsyth
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E



BLOCK DIAGRAMS ILLUSTRATING TYPICAL APPEARANCE
OF PHYSIOGRAPHIC UNITS USED IN THIS REPORT
Figure 6

availability of water generally prevail The following paragraphs describe the units portrayed on the physiographic map and Figure 6.

DL and DL-T

Much of the study area consists of well dissected uplands which are composed of sedimentary rocks dipping at very low angles (less than 5^{o}- 10^{o}). Local relief in these areas is typically several hundred feet or more. Most of the smaller streams are intermittent with "V" shaped valleys which do not have flood plains. The hill sides tend to be steep and often rocky. Locally, extensive cliffs of the bedrock form the sides of hills. Flat surfaces of terraces, older erosional surfaces, or resistant cap rock do not constitute a significant portion of this map unit. Significant flat, high-level surfaces, where present, are mapped separately. Terrain within these units generally has little linearity.

MDL and MDL-T

A small amount of the study area consists of terrain similar to the dissected uplands as described above but with significantly more relief and steeper slopes. The Little Wolf Mountains contain this class of terrain. Here, local relief well exceeds 1,000 feet.

BL

Badlands are areas which have very closely spaced gullies. The land surface consists almost entirely of steep gully sides which make the area rather impassable. Although there are small

areas which could be called badlands throughout much of the study area, areas large enough to be mapped exist only in the northeast corner of the study area.

PL and PL-T

Another common physiographic unit in the study area is the poorly/partially dissected uplands on low-dipping sedimentary rocks. Local relief is generally less than in the previously described units and may contain significant areas of flat, high-level surfaces. The small stream valleys may have either a narrow "V" shaped cross section between the flat-topped divides or a shallow "U" shaped cross section where the local relief is small. Terrain within these units generally has little linearity.

UL

Significantly large areas within the study area consist of undissected, high-level surfaces. Some of these surfaces are old river terraces along the Yellowstone and others are old erosional surfaces lying 1,000 feet or more above the existing Yellowstone. Some of these higher surfaces are mantled by stream gravel. Other flat, high-level surfaces may be the result of horizontal resistant beds acting as a cap rock.

CL

In very gently dipping or horizontal sedimentary rocks, especially when a resistant stratum is present, headward erosion may proceed along a line. The resultant landform is a cliff or

closely spaced group of cliffs which separate a higher-level area from a lower area where the strata forming the cliff have been removed. This escarpment is typically a landform which is narrow with respect to its length. The best example of this kind of feature in the study area is the unit found north of Billings and east of Comanche Basin. Here the escarpment is 200 feet or more in height.

HS

The dip of sedimentary rocks strongly influences the type of landforms present. Unlike the terrain on horizontal or nearly horizontal beds which often has little linearity, a noticeable linearity or "grain" exists where the rocks are tilted significantly from the horizontal. If resistant strata alternate with weaker ones, a series of cuestas, hogbacks, or other features are commonly formed, depending upon the angle of dip (tilt). The angle of dip at which the physiography reflects the difference between the gently dipping beds and the more steeply dipping beds is about 5-10 degrees although factors other than dip have a bearing on this situation.

Where the nature of the landforms in a given area strongly reflect the influence of dipping beds and the local relief is moderate or greater (hundreds of feet), the unit is given the "HS" designation.

LS

The "LS" unit is an area where strong linearity exists due to the dipping beds but where local relief is small. Only one location in the northeast part of the study area has this designation.

DT

A large region near the Snowy Mountains consists of dissected gravel terraces and sediments. This unit is designated only in the northwest part of the study area.

V

The valley floors of the larger streams are made up of the flood plain and low lying terraces. Gentle slopes, thick soils, and the availability of water (for both irrigation and the roots of certain plants) make the valley floors well suited for agriculture and human habitation. Especially in the valleys of the larger streams, the division between the valley floor and the surrounding uplands is often quite sharp. Escarpments of several hundred feet commonly mark the edge of these units.

An examination of the geologic history, structure and stratigraphy of the study area may be found in Appendix A. Also included in the appendix is a discussion of the economic geology of the area.

6.2.2 Hydrology

6.2.2.1 Surface Water

Surface water in the study area, as depicted on the accompanying map, consists of the streams (major and minor), marshes, small ponds, lakes, and certain ephemeral lakes such as those in the area near Broadview in the Comanche Basin. There are also many small stock watering reservoirs scattered across the area. Most of these ponds are only a few acres or less in size and are generally created by simple earthen dams built across gullies to catch the occasional runoff. There are no permanent large reservoirs within the area. In the western part of the area there are a number of ephemeral lakes. These features contain water only at certain times and range in size from a few acres to ten or more square miles.

Streams

The majority of streams in the study area are ephemeral. Even some of the larger streams, including the Tongue River, become completely dry at times. The largest stream in the study area is the Yellowstone River which drains most of the study area. The remainder is drained by the Musselshell River. The Yellowstone River lies far to the north of the center of its drainage basin. Although this river drains much of northern and central Wyoming, it drains only a small area to the north. All of the major tributaries of the Yellowstone enter from the south--two of them (the Clarks Fork and the Bighorn) doing so within the study area.

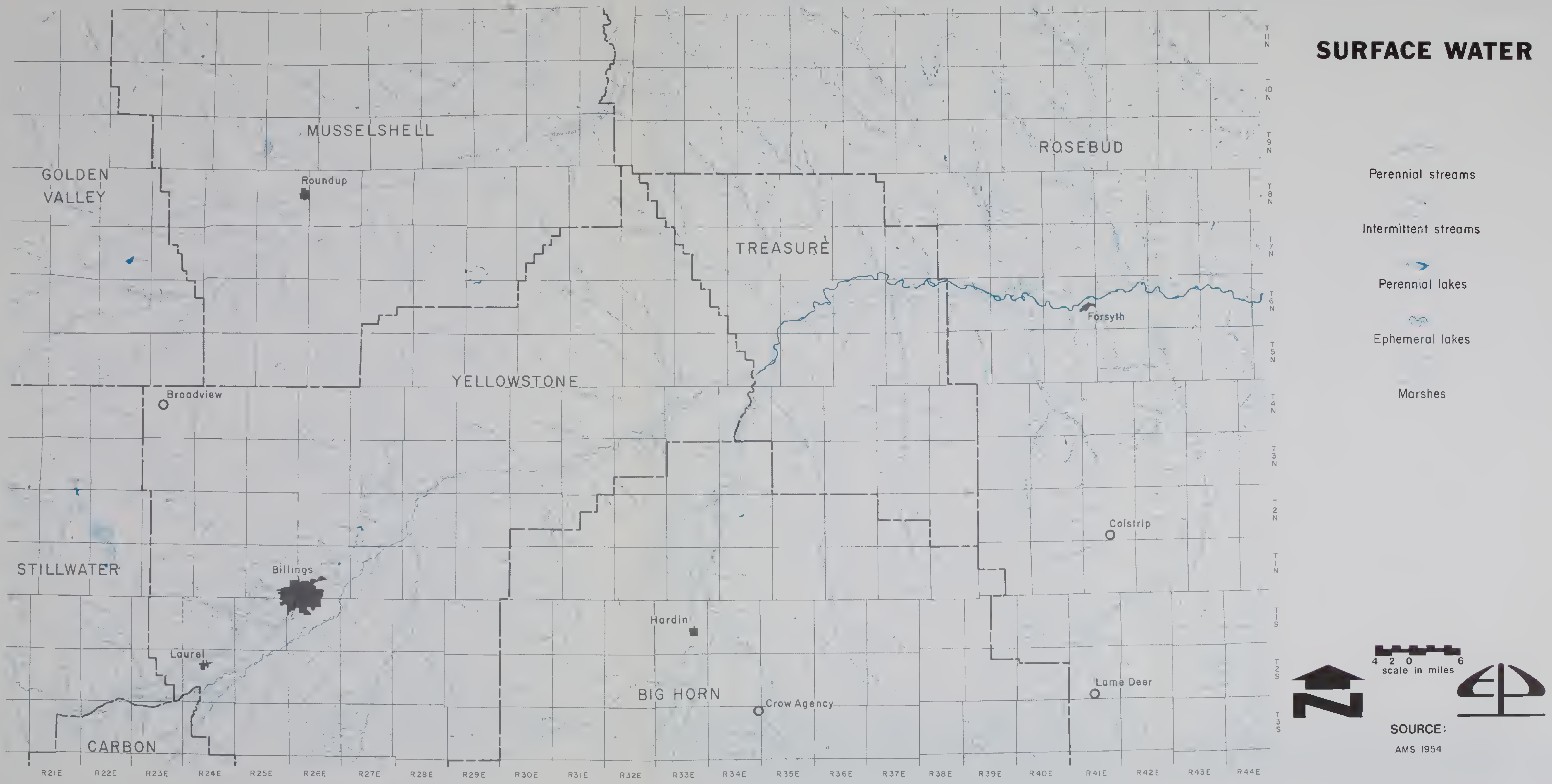
The Yellowstone and Musselshell are free-flowing rivers whereas the Bighorn and Tongue Rivers are largely controlled by reservoirs which lie upstream of the study area. The U.S. Geological Survey has delineated the flood hazard area for the Yellowstone and Bighorn River portions of the study area. The flood plains are not shown on the accompanying maps because of the small scale of the maps.

Appendix D gives flow data for the larger streams in the study area.

Ephemeral Lakes

Notably in Comanche and Lake Basins there are topographic lows that collect water in wet weather but are dry for considerable amounts of time. At least some of these lakes appear to have been permanent lakes of much greater size in the past, possibly during Pleistocene time (from 10,000 to two million years ago). The marshy basin south of Broadview is usually dry, but in wet years the area will be covered by water in the spring and sometimes into early summer. This basin is floored by a fine silty clay which will not support the weight of vehicles when wet. The basin is not flooded for long enough periods of time to kill the grass which covers the lowest areas. According to a local resident, hay is grown on this land except in unusually wet years.

A number of ephemeral lakes ranging in size from a couple of acres to several square miles also exist in Lake Basin. Some of these lakes, especially some of the smaller ones, appear to have been formed by deflation.



SURFACE WATER
Perennial streams
Intermittent streams
Perennial lakes
Ephemeral lakes
Marshes
MUSSELSHELL
ROSEBUD
GOLDEN VALLEY
Roundup
TREASURE
Forsyth
YELLOWSTONE
Broadview
Colstrip
STILLWATER
Billings
Hardin
Laurel
BIG HORN
Crow Agency
Lame Deer
CARBON
scale in miles
4 2 0 6
SOURCE:
AMS 1954
T 11 N
T 10 N
T 9 N
T 8 N
T 7 N
T 6 N
T 5 N
T 4 N
T 3 N
T 2 N
T 1 N
T 1 S
T 2 S
T 3 S
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E

The large basin south of Broadview contains some dune-like ridges trending north-south which are only a few feet in height. It is not clear whether these features are caused by processes which are still acting or by formerly dominant processes. In either case, they appear to have an eolian origin.

6.2.2.2 Groundwater

The permeable bedrock formations that form aquifers within the study area are mainly sandstone, coal, and clinker. Permeability of the sandstone is mostly due to original porosity, whereas coal and clinker owe their permeability to the presence of abundant fractures. Shale, the other major rock type in the study area, is generally very impermeable and thereby restricts groundwater flow.

Where the permeable units crop out or lie immediately beneath streams or saturated stream sediments, they collect precipitation or stream flow which slowly migrates down the slope of the formation in response to gravity. This groundwater may emerge elsewhere in springs or wells.

The coarser alluvial deposits, including Recent stream deposits as well as ancient river terrace and plateau deposits, provide good reservoirs.

For the most part, groundwater within all of these aquifers is too deep to be affected by surficial construction activity. Only in special, local circumstances is groundwater of concern with respect to transmission lines.

6.2.3 Soils

It is estimated there are 50 different soils in the study area. The "General Soils" map shows these in 23 soil associations (groups of defined soils regularly associated geographically in a proportional pattern). The soils that make up the 23 major soil associations are identified in descriptive terms based on physiographic position and kind of parent materials. Appendix B contains a list of definitions of soil terms, a general representative soil profile with each soil keyed to the soil association in which it occurs, and a brief description of each association. The following list of soil association groups are shown on the "General Soils" Map also located in Appendix B.

GROUP 1 Soils of the Stream Valleys

GROUP 2 Deep and moderately deep, well-drained soils of the high and intermediate gravel capped benches and terraces.

GROUP 3 Moderately deep and shallow clay soils formed from shales on the undulating to hilly sedimentary uplands.

GROUP 4 Moderately deep and shallow soils formed from weakly consolidated siltstones and sandstones on the undulating to very steep and rough broken sedimentary uplands.

GROUP 5 Moderately deep and shallow soils formed from consolidated sandstone or interbedded, hard sandstones and shales on nearly level to very steep sedimentary uplands.

GROUP 6 Moderately deep and shallow red-colored soils on the rolling, hilly and very steep scoria and porcellanite uplands.

GROUP 7 Mountainous Lands

Erosion Hazard

Erosion hazards indicate susceptibility of soil to erode when vegetative cover is removed. Some of the factors used as a guide in rating the erosion hazard of soil associations were: (1) soil texture including coarse fragments of gravel and cobble, (2) steepness and length of slope, (3) degree of soil development (formation process) including soil aggregation, and (4) type of seasonal precipitation.

The 23 soil associations have been divided into three broad erosion hazard classes of slight, moderate and severe as shown by the accompanying map ("Soil Erosion Hazard"). With this type of classification scheme, soil associations with very dissimiliar taxonomic properties may be placed in the same erosion hazard class, since they present the same degree of limitation to transmission line construction and maintenance. For example, a high percentage of coarse soil (resisting detachment and movement) in a soil profile would balance out the effect of steep slopes, resulting in the same "slight" rating as a soil devoid of coarse fragments but on gentle slopes.

Within a soil association there will be differences too small to show at the map scale chosen. These local variations may make it possible to locate a transmission line with less severe impact than would be expected from the broad rating of the larger unit.

Soils rated as "slight" range from relatively free of potential erosion hazards to hazards that are easily overcome at little or no cost.

Soils rated as "moderate" have potentially significant erosion hazards, but these can be overcome with proper design and construction methods.

Soils rated as "severe" range from areas of very significant potential erosion hazards that can be minimized by very careful design, location and construction techniques at high cost, to areas where there is no way to avoid erosion and sediment risk.

The placement of the soil associations in the three erosion hazard classes are:

A. Slight Erosion Hazard

Soil associations -- 1A, 1B, 1C -- deep loamy and clayey soils on gentle flood plains, fans and low terraces.

Soil associations -- 2A, 2D, -- deep gravelly loam and gravelly clay loam soils on long smooth sloping and very sloping high benches.

Soil associations -- 2B, 2C, -- deep and moderately deep clay soils on sloping high benches.

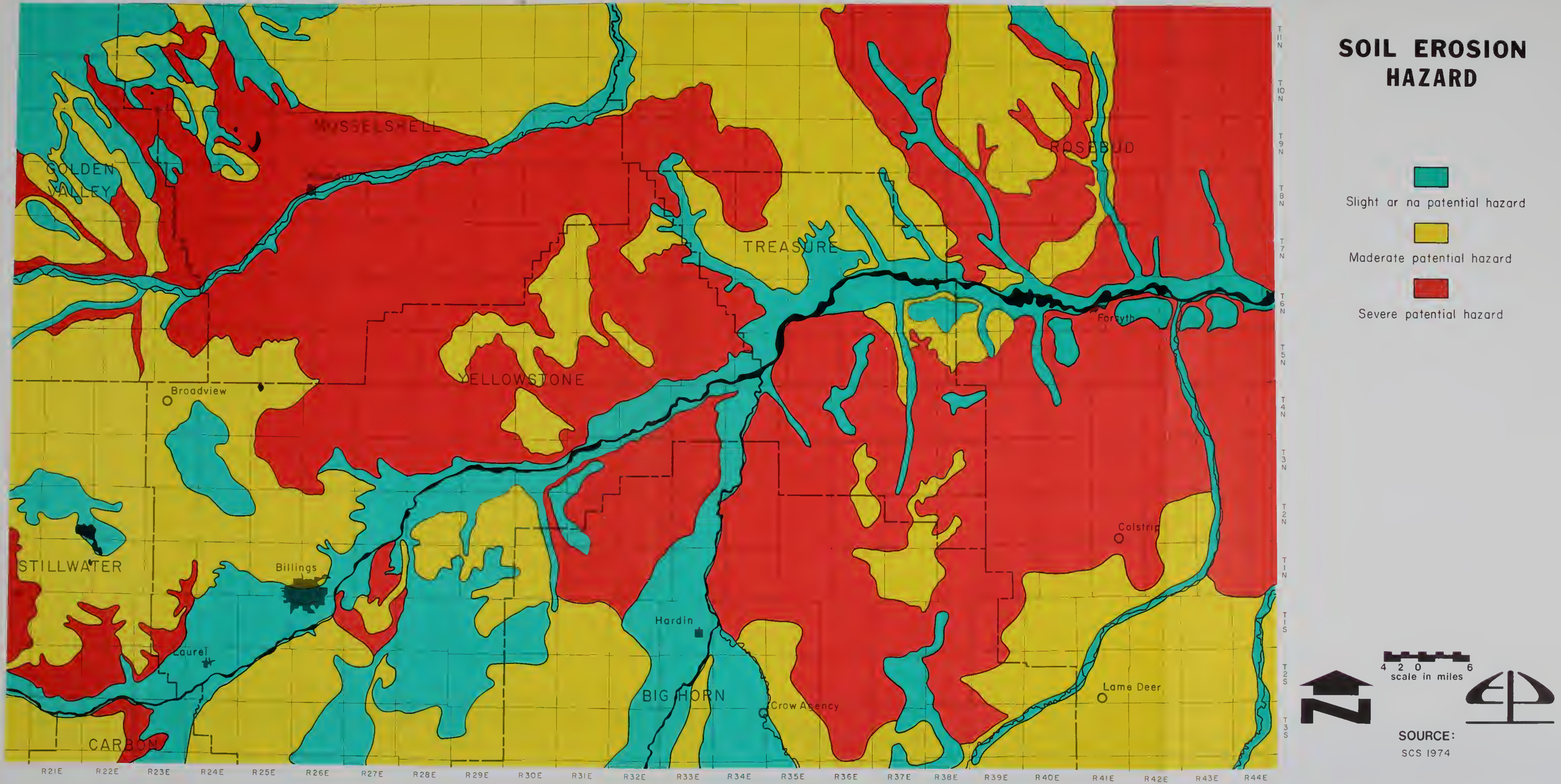
Soil association -- 4C -- deep and moderately sandy soil on sloping uplands underlain by consolidated sandstone.

Soil association -- 4F -- deep, clayey soils on low terraces of the stream valley.

Soils association -- 7 -- deep, very gravelly loamy soils on mountain slopes.

B. Moderate Erosion Hazard

Soil associations -- 3A, 3B -- moderately deep, deep and shallow soils on sloping and very sloping heavy clay shale uplands.



SOIL EROSION HAZARD
Slight or no potential hazard
Moderate potential hazard
Severe potential hazard
MUSSELSHELL
GOLDEN VALLEY
ROSEBUD
TREASURE
YELLOWSTONE
STILLWATER
BIG HORN
CARBON
Roundup
Broadview
Billings
Laurel
Hardin
Crow Agency
Forsyth
Colstrip
Lame Deer
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S
4 2 0 6
scale in miles
SOURCE:
SCS 1974

Soil associations -- 4B, 4G -- moderately deep and shallow loamy and sandy soil on sloping and rolling uplands developed from weakly consolidated sandstone and siltstone.

Soil associations -- 5A, 5D -- moderately deep and shallow clayey soils on gentle sloping to very sloping uplands underlain by hard sandstone or on mixed sandstone and shale.

Soil associations -- 6A, 6B -- shallow and moderately deep loamy soils on rolling uplands developed from scoria.

C. Severe Erosion Hazard

Soil associations -- 4A, 4D -- moderately deep and shallow loamy and clayey soils on rolling or steep uplands developed from weakly consolidated sandstone and siltstone.

Soil associations -- 4E, 5B, 5C -- shallow, clayey soils and rock outcrop on steep and very rough uplands of sandstone, siltstone and shale.

6.2.4 Vegetation

6.2.4.1 Classification

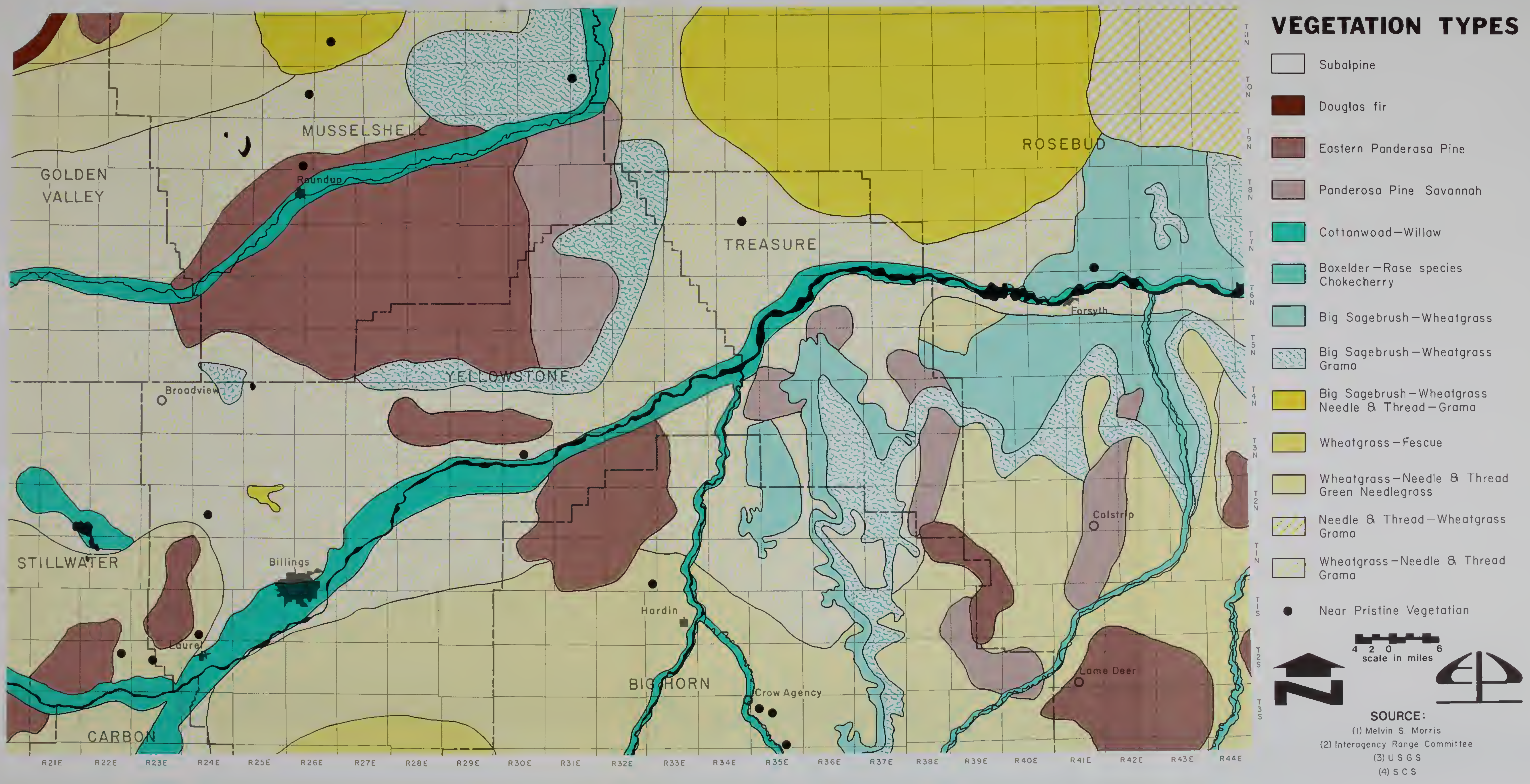
The study area lies in the Northern Great Plains physiographic province. Vegetation consists of pine savannah, pine forests and a mixture of grassland sagebrush and sagebrush grassland. The grasslands of the area are in the mixed prairie complex. Broadleaf trees and shrubs occur along rivers and stream drainages. This broad vegetation classification is further broken down by dominant species into thirteen vegetation types (see Map "Vegetation Types"). The major source for the vegetative map

is Natural Vegetation of Montana (Morris, 1964) with some modifications made to include closer analysis of geology and soils.

The subalpine type is represented in only a small area in the northwestern corner. This mountain area (from 5,000 feet to timberline) receives considerably more precipitation (30-40") than the plains area. Lodgepole pine (*Pinus contorta*) alpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) are common associates in this type. Whitebark pine (*Pinus albicaulis*) may also occur.

The Douglas fir type is found lower on the mountain slopes (3,000' to 6,000') than the subalpine type and is in a lower precipitation (20-30") zone. The major species of this type is Douglas fir (*Pseudotsuga menziesii*). Other tree species include Englemann spruce and subalpine fir in the higher levels of the zone and ponderosa pine (*Pinus ponderosa*) at lower levels. Lodgepole pine and quaking aspen (*Populus tremuloides*) are present, in some areas, depending on past fire history.

On the dryer, lower sites (12-18" precipitation) the eastern ponderosa pine type occurs. Rocky mountain juniper (*Juniperus scopulorum*) may be associated with ponderosa pine, especially on the poorer, droughty soils of the shaley breaks. Other common associates are skunkbrush sumac (*Rhus trilobata*), bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), sideoats grama (*Bouteloua curtipenedula*), and little bluestem (*Andropogon scoparius*). This type occurs on the Hell Creek geologic formation in the Roundup area and in scattered continuous stands east and south of Colstrip (see Vegetation Types map).



VEGETATION TYPES
Subalpine
Douglas fir
Eastern Panderosa Pine
Panderosa Pine Savannah
Cottanwood—Willow
Boxelder—Rase species Chokecherry
Big Sagebrush—Wheatgrass
Big Sagebrush—Wheatgrass Grama
Big Sagebrush—Wheatgrass Needle & Thread—Grama
Wheatgrass—Fescue
Wheatgrass—Needle & Thread Green Needlegrass
Needle & Thread—Wheatgrass Grama
Wheatgrass—Needle & Thread Grama
Near Pristine Vegetation
4 2 0 6
scale in miles
SOURCE:
(1) Melvin S. Morris
(2) Interagency Range Committee
(3) U S G S
(4) S C S
MUSSELSHELL
GOLDEN VALLEY
Roundup
ROSEBUD
TREASURE
YELLOWSTONE
Broadview
Forsyth
STILLWATER
Billings
Colstrip
Hardin
Laurel
BIG HORN
Crow Agency
Lame Deer
CARBON
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S

The denser stands occur on north, east, and northeast aspects. Ponderosa pine occurs on sandy breaks.

Grassland communities are better able to withstand drought conditions than tree species. Throughout the study area the grassland and sagebrush grassland types occur in the 12-14" annual precipitation zone.

The wheatgrass-fescue type receives slightly more annual precipitation than the other grassland types. On the bottomland areas of its distribution the annual precipitation is from 14-15" and on the foot slopes it will occur on areas receiving up to 18" annual precipitation. This type is found in the northwestern and southwestern portions of the study area just below the ponderosa pine type. Bluebunch wheatgrass appears on the lower south and southwest facing slopes. It generally prevails on gravelly and sandy soils and also appears on soils having cracks at the surface extending down into the "C" horizon of the soil profile where moisture can accumulate such as on badland ridges (Morris, 1973). Other species commonly associated with bluebunch wheatgrass are prairie junegrass (*Koleria cristata*), native bluegrass (*Poa secunda*), and needle and thread (*Stipa comata*). Under heavy grazing pressure, bluebunch is replaced by native bluegrass. The fescues, rough fescue (*Festuca scabrela*) and idaho fescue, generally occur in areas of 14" annual precipitation or greater. On the north and east slopes rough fescue, idaho fescue, and bluebunch wheatgrass are dominant. However, with increases in elevation, either rough or Idaho fescue dominates and bluebunch is uncommon. The fescues grow on moderately deep soils that are light to medium textured. Species commonly associated with the fescues in this type are

Richardson needlegrass (*Stipa richardsonii*), timber oatgrass (*Danthonia intermedia*), and parry oatgrass (*Danthonia parryi*).

The ponderosa pine savannah type is a mixture of isolated pine trees and grassland. This type occurs in the 12-14" annual precipitation areas on the breaks and terraces above flood plains such as those near the Yellowstone River and Rosebud Creek. Rocky Mountain juniper may also be found in this type. Other common major associates are skunkbrush sumac, western wheatgrass (*Agropyron smithii*), bluebunch wheatgrass, and blue grama (*Bouteloua gracilis*). As with the type just mentioned, the ponderosa pine grow on sandy knolls and the greatest number occur on north facing slopes (Ballard, Ryerson, 1973). Big sagebrush (*Artemisia tridentata wyomingensis*) also occurs in this type.

The big sagebrush-wheatgrass type occurs on the Tullock member of the Fort Union geologic formation. The boundary of this type should be considered very general because of incomplete geological mapping and no sharp ecotone between sagebrush and grassland. Within the Tullock member there are some relatively pure grassland areas. The Tullock is not amenable to sharply delineated vegetation boundaries because it contains good sandy areas and many shale areas. Grass and shrub combinations are generally tied to sandy soils while sagebrush alone is more associated with shaley soils. Even within the sagebrush areas there may be a combination of big and silver sagebrush (*Artemisia cana*). When using soil classifications to a series level for mapping boundaries, it should be noted that some soil series reveal contradictions due to past history (over-grazing and fire). In general,

sagebrush occurs on vertisols and coarse soils. Associated with the big sagebrush-wheatgrass type are yucca (Yucca glauca) and needle-and-thread grass.

The big sagebrush - wheatgrass - grama type was mapped using the boundaries of the Lebo member of the Fort Union formation. The Lebo can be used as a strong indicator of big sagebrush boundaries, especially if there is any relief in topography. However, as with the previous type, absolutes are dangerous. For example the Lebo shale has some pure grasslands in it, especially on nearly level terraces (uplands). On clay soils and sandy areas, silver sage also occurs. Blue grama grows on a variety of soil textures but generally is more abundant on flat to southerly exposures. Blue grama abundance is also strongly connected with grazing history. On clay loams and sandy loams in a 12-16" annual precipitation zone and with moderate grazing intensity, blue grama take the position of second or third order of dominance. However, given the same conditions except with heavy grazing intensity, blue grama assumes a first order dominance (Morris, 1954). The following example demonstrates the tremendous diversity of the type on two different sites within its boundary. On one site near the turn-off from Sarpy Creek to Colstrip on fairly smooth rolling topography, the dominant species in order of abundance were: 1. big sagebrush, 2. western wheatgrass, 3. blue grama. On another site, this time a shale outcrop, the dominant species were: 1. big sagebrush, 2. prairie sandreed, (Calamouilfa longifolia), 3. yucca.

The wheatgrass-needle and thread-green needlegrass type, needle and thread-wheatgrass-grama type, wheatgrass-needle and thread-grama type and the big sagebrush-wheatgrass-needle and

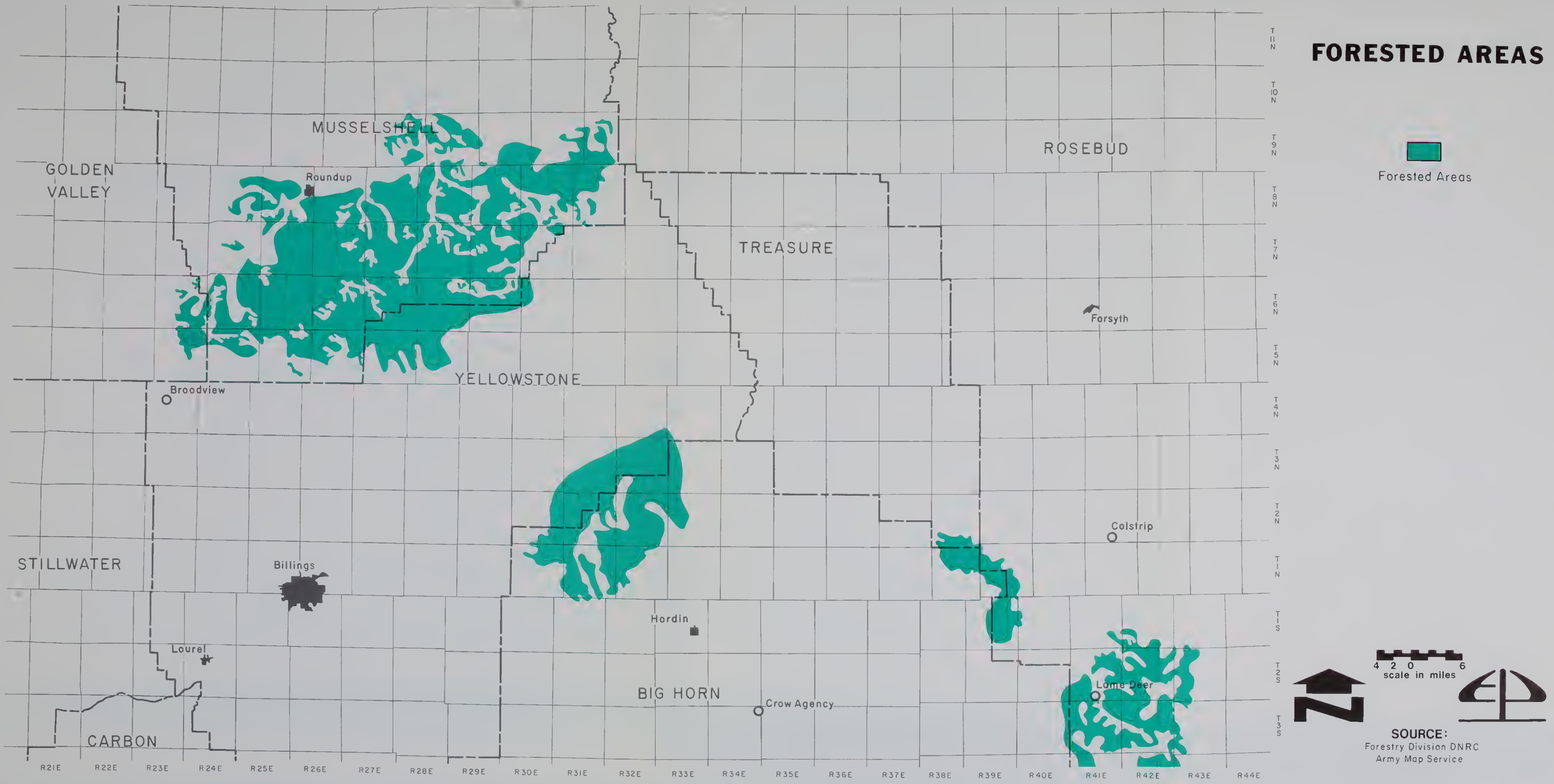
thread-grama type are very similar and are separated only by species dominance due to differences in soil texture. Western wheatgrass is dominant in swales and when there is clay or clay loam in the "B" horizon. Green needlegrass (Stipa viridula) is commonly associated with western wheatgrass and is more abundant on cracking clays (vertisol soils), especially silty clay loam, but is very sensitive to grazing pressure and is the first to drop out. Needle and thread grass is dominant if the "A" and "B" horizons are silty to sandy loams. Thread leaf sedge (Carey filitolia) is a common associate with needle and thread. Blue grama occurs on a wide variety of soils but is more prevalent on drier sites and increases in dominance with greater grazing pressure. Big sagebrush is the leading dominant species in areas that have fairly shallow "A" horizons, warm sites (sloping to the south) and heavier grazing activity. Big sage also prevails on shaley soils of the uplands.

There are two riparian vegetation types occurring on alluvial bottoms. The cottonwood-willow type occurs primarily along the Musselshell, Yellowstone, and Bighorn Rivers, while the box elder-rose-chokecherry type occurs primarily along the Tongue River and Rosebud Creek. Other species associated with these types are rose (Rosa spp.), dogwood (Cornus spp.), buffalo berry (Shepherdia argentea), snowberry (Symphoricarpos albus), chokecherry Prunus virginiana), and silver sage.

6.2.4.2 Forest Resource

As indicated by the map, "Forested Areas", there are four main areas of eastern ponderosa pine type that are relatively continous

FORESTED AREAS



SOURCE:
Forestry Division DNRC
Army Map Service

stands. These stands were mapped using ERTS imagery and existing forest maps. All of the inventory data is for the Bull Mountains area with very little diameter and volume data for the other areas. Considering only state-owned land that is classified as forest land, there are 6,134 acres of commercial forests and 3,639 acres of non-commercial forests in the study area. Commercial forests are those stands having a diameter of at least 5" at breast height (d.b.h.). This includes both pole size (5"-11" d.b.h.) and saw timber size (11" d.b.h. and greater) trees. Average diameter for this forested area is 10 to 11" d.b.h., although some trees may exceed 11" d.b.h. (Pike, 1974; Roberts, 1974).

Tree heights in the Bull Mountains area and in the forested area south of Pompey's Pillar are shorter than in the moister areas in the eastern and southern parts of the study area; consequently, the mean volume of trees per acre of 1,500 to 4,000 board feet (bf.) is low.

The forested area south of Pompey's Pillar and the Yellowstone River has about the same volume as that mentioned for the Bull Mountains. The better quality saw timber is in the northern part of Yellowstone County. This quality decreases moving south into Bighorn County.

The Divide area west of Colstrip has ponderosa pine trees averaging 13-14" diameter with volume of trees per acre varying from 5,500 bf. at the crest and slightly east and west of the crest, to 2,000-3,000 bf. on the footslopes further east and west of the divide. The footslopes also have fewer trees per acre. (Pike, 1974).

The forested area near Ashland has an average tree diameter of 15 - 16" and volume per acre ranging from 6,000 - 9,000 bf.

Large cottonwood trees along the Yellowstone River are also a potential saw timber resource that is being harvested.

The study area has approximately 14 sawmills that serve certain commercial portions of the area. Most of the small mills have maximum hauling distances of about 50 miles. However, the larger mills, including some in Wyoming, have maximum hauling distances of 75-150 miles.

The remainder of the forest resource consists of small, discontinous stands that are primarily on the cooler northern and eastern slopes. Small diameter trees and uneconomical hauling distances limit use except locally for posts and poles, and small marginal sawmills.

6.2.4.3 Range Resource

Range Production

Range production is indicated in terms of animal unit months (AUM). An animal unit is considered to be a 1,000 lb. cow or its equivalent. An animal unit month is the amount of forage or feed required by an animal unit for one month. Factors playing a part in range production are climate, soils, grazing history, and past and present livestock management practices. In the study area, using Soil Conservation Service criteria, the range production is fair to good, approximately 4-7 acres per AUM; however, there are areas in worse condition that require far more acres per AUM. Examples of this in the study area are the badlands and

Porcupine dome. On the other hand, there are areas in excellent condition, such as bottomland, requiring fewer acres per AUM.

Range Condition

Range condition in the study area is determined on the basis of percent of original plant cover and the species compostion which makes up the vegetation types. Four ratings are used to indicate range condition. These are excellent, good, fair, and poor. An excellent condition rating means that from 75-100% of the original plant species are present, given certain soil and climatic conditions. Good condition equals 50-75%, fair condition equals 25-50% and poor condition equals 0-25% of the original plant cover given certain conditions of soil and climate.

An overall condition rating for the study area can not be exactly stated. However, with available data for the individual counties in the study area, some indication of condition is possible (Jackson, 1973). The amount of range in good to excellent condition is approximately equal to 49.4% and that in less than good condition is approximately equal to 50.4%.

Noxious and Poisonous Plants

Within the study area several plant species exist that are classified as noxious or poisonous.

A noxious plant is "an undesirable plant species that is unwholesome to the range or animal"; whereas, a poisonous plant is, "a plant containing or producing substances that cause sickness, death or a deviation from normal state of health of animals" (Huss et. al., 1964).

The most common noxious plants within the study area are Russian thistle (Salsola kali), knapweed (Centaurea maculosa), fringed sage (Artemisia frigida), broom snakeweed (Gutierrezia sarothrae), prickly pear (Opuntia polyacantha), canadian thistle (Cirsium arvense), and field bindweed (Convolvulus arvensis) (BLM, 1971). Low palatability for livestock use is the main reason for classification as noxious species. Of the above mentioned species, knapweed distribution is increasing along the Yellowstone River and Canadian thistle is increasing in the area of Armells Creek.

Poisonous plant species common to the area are black greasewood (Sarcobatus vermiculatus), chokecherry (Prunus virginiana), arrowgrass (Iriglochia maritima), cockleburr (Xanthium strumarium), death comas (Zigadenus venenosus), lupine (Lupinus candatus), locoweed (Astragalus spp.), and leafy spurge (Euphorbia esula). Of these species black greasewood is the most common; however, no livestock losses have been reported in connection with it (BLM, 1969 and 1971). Cockleburr is responsible for a few livestock losses each year where it has a chance to establish itself on raw soils (BLM, 1969 and 1971). Arrowgrass is common in small patches in the Yellowstone River subbasin and is very deadly. However, no losses have been reported which may be attributed to it (BLM, 1965). Two potentially poisonous plants which occur throughout the area are chokecherry and lupine. Both of these species are frequently used as forage by livestock and wildlife, but no livestock losses have been reported (BLM 1969 and 1971).

Poisonous plants generally are dangerous only at certain times of the year (varies by species) and can be avoided through

good management practices.

Plant succession on disturbed areas depends on the plant species in the adjacent areas. Thus, extreme caution should be used to avoid increases in distribution of noxious and poisonous plants due to construction and maintainance practices which disturb the natural vegetation and leave raw soil exposed.

Range Trend

At present the range trend is on an incline in the study area. This situation, however, is primarily due to above normal annual precipitation over the past ten years and does not generally reflect the use of better or more intensive management practices in the area. There may be a tendency on the ranchers' part to increase the number of stock on the range, which may reverse the range trend.

6.2.5 Wildlife and Fisheries

Important game animals located in the Colstrip to Broadview area include mule deer (*Odocoileus hemionus*), white-tail deer (*Odocoileus virginianus*), antelope (*Antilocapra americana*), sage grouse (*Centrocercus urophasianus*), sharp-tail grouse (*Pediocetes phasianellus*), pheasants (*Phasianus colchicus*), and waterfowl. Distribution, habitat, and food habits of these species and others will be discussed separately in following portions of this report. The maps "Wildlife - Mammals" and "Wildlife - Birds" maybe consulted for the species described in the text.

It should be noted that the colors of the numbers (representing habitat quality) used on both maps and the colors assigned to individual species correspond. Thus, the numbers' color indicates the species being described.

Most of the information contained herein came from personal contacts with biologists from the Montana Department of Fish and Game, personnel with the Bureau of Land Management and from Department of Fish and Game completion reports. A small amount of field work was conducted in areas where specific information was not available.

6.2.5.1 <u>Wildlife</u>

<u>Game Mammals</u>

There are two distinct elk (<u>Cervus canadensis</u>) herds in the study area, one located in the Bull Mountains and the other in the Pine Ridge area. The present population estimate is 75-100 and 15-45 head, respectively (Dusek, Compton and Good, 1974). It is believed that the Bull Mountains elk emigrated from the Pine Ridge herd in the early 1950's. Elk were released on Pine Ridge by private individuals in the 1940's. The probable emigration corridor is shown on the map along with critical winter range. In an area similar to the study area, Mackie (1970) reported that grasses were the most important year-long source of forage for elk, followed by forbs and shrubs with 58, 29 and 13 per cent use respectively. Western wheat grass (Agropyon smithii). sweetclover (<u>Melilotus officinalis</u>) and big sagebrush (<u>Artemisia tridentata</u>) were the most important forage. The habitat type in


WILDLIFE MAMMALS
Elk Habitat
Elk Habitat Critical Areas
Elk Emigration
Antelope Habitat
Antelope Habitat Summer Range
Antelope Habitat Winter Range
Mule Deer Habitat
Mule Deer Habitat Winter Range
Whitetail Deer Habitat
Mule Deer & Whitetail Deer Habitat
Prairie Dog Towns
Habitat and/or Population Quality
1-None to Low
2-Low to Moderote
3-Moderote to High
4-Criticol Areas
4 2 0 6
scale in miles
SOURCE:
Montona Department of Fish & Game
BLM
1974
GOLDEN VALLEY
MUSSELSHELL
LAKE MASON NATIONAL WILDLIFE REFUGE
Roundup
TREASURE
ROSEBUD
YELLOWSTONE
Broadview
HAILSTONE NATIONAL WILDLIFE REFUGE
HALFBREED LAKE NATIONAL WILDLIFE REFUGE
STILLWATER
Billings
Laurel
CARBON
Hardin
BIG HORN
Crow Agency
Forsyth
Colstrip
Lame Deer
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S


WILDLIFE
BIRDS
Pheasant Habitat
Turkey Yearlang Habitat
Turkey Wintering Areas (Critical)
Waterfawl Breeding & Wintering Areas
Waterfawl Breeding Areas
Sage Grause Strutting Ground (Critical Areas)
Sharptail Grause Dancing Ground (Critical Areas)
Heran Raakery
Habitat and/ar Papulatian Quality
3-Moderate to High
4-Critical Areas
4 2 0 6
scale in miles
SOURCE:
Montana Department of Fish & Game
BLM
1974
LAKE MASON NATIONAL WILDLIFE REFUGE
MUSSELSHELL
ROSEBUD
GOLDEN VALLEY
Roundup
TREASURE
YELLOWSTONE
Forsyth
Broadview
HAILSTONE NATIONAL WILDLIFE REFUGE
HALFBREED LAKE NATIONAL WILDLIFE REFUGE
STILLWATER
Billings
Colstrip
Hardin
Laurel
Lame Deer
BIG HORN
Craw Agency
CARBON
T11N
T10N
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R41E
R42E
R43E
R44E

which elk were most often observed was sagebrush-wheatgrass (*Artemisia*-*Agropyron*) followed by pine-juniper (*Pinus*-*Juniperus*). There has been no controlled hunting on either of these herds.

Mule deer are the most abundant big game species in the study area. They are distributed throughout the entire area and are generally nonmigratory. The only critical winter range identified is in the Bull Mountains (Dusek, 1974). Browse is the most important forage source (Eustace , 1971; Dusek, 1971; Knapp, 1972; and Mackie, 1970). Key browse transects have been established for rubber rabbitbrush (*Chrysothamnus viscidiflorus*),green rabbitbrush (*Chrysothamnus nauseosus*), skunkbush sumac (Rhus trilobata), big sagebrush (*Artemisia tridentata*), silver sagebrush (*Artemisia cana*), chokecherry (*Prunus virginiana*), and snowberry (*Symphoricarpos alba*). These are in good to excellent condition (Eustace , 1973). The pine-juniper habitat type receives the most use in summer with sagebrush-wheatgrass being the most important the remainder of the year (Mackie, 1970; Gordon and Coop, 1973).

Whitetail deer are found primarily along the Yellowstone, Bighorn and Musselshell River bottoms and their larger tributaries within the study area throughout the year. These bottomlands and their associated deciduous vegetation are critical for viable whitetail populations. Western snowberry (*Symphoricarpos occidentalis*) was the most important forage source, followed by cottonwood (*Populus* spp.), in a food habits study conducted in the Missouri River breaks (Allen, 1968). Whitetails comprise a small but consistent proportion of the annual harvest and are maintaining stable or increasing populations (Eustace, 1973; Gordon and Coop, 1973).

Pronghorn antelope occur throughout the study area in numbers second only to mule deer. Highest densities are found north of the Yellowstone River and lowest densities in the Bull Mountains and the area east of the Bighorn River south of the Yellowstone. Wintering areas are closely associated with silver and big sagebrush habitat types (Gordon and Coop, 1973). Optimum antelope habitat is open sagebrush-grasslands free of interference by man (Mussehl and Howell, 1971). Sagebrush and forbs, especially fringed sage (*Artemisia frigida*) and yellow sweetclover, are essential forage items in the year-long diet of antelope (Wentland, 1968; Bayless, 1969; and Cole, 1956), with shrubs being most important during winters and forbs most important the remainder of normal years. Antelope numbers have continued to increase despite increased harvests. In recent years, however, range carrying capacities may have been reached in the study area as productivity is now declining (Wentland, 1973; Gordon and Coop, 1973).

Upland Game Birds

Sharp-tail grouse occur throughout the study area with known dancing grounds indicated on the map,"Wildlife Birds" Sharp-tail habitat is characterized by tree-shrub-grasslands located in the upland prairie. Items essential for survival are standing grasses and dense trees and shrubs. These are needed for food, nesting activities, cover and winter survival (Mussehl and Howell, 1971). Sharp-tail breeding population trend data indicate stable or increasing populations (Compton, 1973 and Wentland, 1973).

Sage grouse occur throughout the study area with the exception of the Bull Mountains and the Yellowstone River basin near Billings. Known strutting grounds are indicated on the map. Sage grouse are highly dependent on sagebrush, primarily big sagebrush, for their existence. It comprises almost 100 percent of their winter diet (Mussehl and Howell, 1971). Sage grouse populations appear to be stable in the study area (Compton, 1973; Wentland, 1973).

The ring-necked pheasant occurs in the study area in association with irrigated bottom lands primarily along the Yellowstone and Bighorn Rivers and their major tributaries. Cultivated grain comprises 77 percent of the volume of the birds' crop contents according to one study (Hiatt, 1947). Pheasant populations are increasing in the study area (Compton op. cit.).

Merriam's turkey (Meleagris gallopavo merriami) flocks exist in four separate regions of the study area. Turkeys were released near Sarpy Creek, Forsyth and the Bull Mountains in 1957 and in the Pine Ridge area near Pompey's Pillar in 1965 and 1966 (Mussehl and Howell op. cit.). Turkeys utilize grass during all seasons, insects during summer and domestic grain during winter (Jonas, 1966). Mature ponderosa pine are used for roosting, while dense stands of younger trees are used for escape cover. During winter, turkeys use deciduous trees and shrubs along river bottoms and farm feedlots. These critical areas are shown on the "Wildlife-Birds" map. Production and harvest have fluctuated widely over the course of several years (Wentland op. cit. and Compton op. cit.).

Hungarian partridge (Perdix perdix) are found throughout the study area interspersed in pheasant and sharp-tail habitat, but primarily near crop lands. Production has been down, but

populations at least appear to be stable (Wentland op. cit., Compton op. cit.).

Furbearers and/or Predators

The major furbearers/predators in the study area are beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), raccoon (*Procyon lotor*), fox (*Vulpes fulva*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), long-tailed weasel (*Mustela frenata*), skunk (*Mephitis mephitis*), and badger (*Taxidea taxus*).

Beaver and muskrats are vegetarian and associated with waterways. Mink are found near water but are not restricted to it. Coyotes are found throughout the study area. Raccoons are associated with major waterways while the fox, skunk, badger and weasel are found throughout the study area.

Waterfowl

Key waterfowl breeding and wintering areas occur within the study area. The Yellowstone and Bighorn Rivers are heavily used by wintering ducks of many species. Ducks and geese also nest along both rivers. A key duck breeding area extends from Big Lake across the flats between Acton and Broadview to Hay Basin. The larger lakes, ponds, and playas which dot the area are critical to the breeding population (Witt, 1974).

As part of the Calamity Jane Project, the Montana Department of Fish and Game has plans for flooding the area south of the Comanche Basin in an effort to increase waterfowl breeding habitat (Filger, 1974).

In eastern Montana no narrow waterfowl migration corridors have been mapped, but lotic and lentic habitats are heavily used by migrating waterfowl throughout the study area (Witt, op. cit.).

Rare and Endangered Species

Of the endangered wildlife included in the 1973 "red book", only two taxa may regularly occur in the study area (Bureau of Sport Fisheries, 1973a). Although the American peregrine falcon (*Falco peregrinus anatum*) is not now known to breed in the study area, one eyrie, active within the last five years, is present (Sumner, 1974). Occasional migrants can reasonably be expected to appear throughout the study area.

The last unconfirmed sightings of a black-footed ferret (*Mustela nigripes*) in Montana date from 1970, and no confirmed sightings in Montana were obtained after 1953 (Snow, 1973:3). It is not known whether or not ferrets occur in the study area.

Other Birds

Of special interest is the concentration of wintering bald eagles (*Haliaeatus leucocephalus*) along the Bighorn and Yellowstone Rivers. In an aerial survey of the Yellowstone River made during March, 1974, 261 bald eagles were counted along the river from Billings to Intake. This bald eagle concentration ranks among the most impressive recorded for the upper United States (McClelland, 1973; Southern, 1964).

6.2.5.2 Fisheries

The Yellowstone and its tributaries within the study area support primarily "warm water" fish species, with the exception of several reservoirs which have been stocked with trout. The most important game species in the Yellowstone River between Billings and Forsyth are sauger (Stizostedion canadense), burbot (Lota lota), and channel catfish (Ictalurus punctatus). Paddlefish (Polydon spathula) are primarily found downstream from Forsyth, but individuals are occasionally encountered as far upstream as Billings (Bishop, 1974). The waters of the study area also support many non-game and less common game species. Fish recovered from 23 gill nets set in the Yellowstone between Laurel and Myers include the following:

- Brown Trout (Salmo trutta)
- Rainbow Trout (Salmo gairdneri)
- Goldeye (Hiodon alosoides)
- Carp (Cyprinus carpio)
- Black Bullhead (Ictalurus melas)
- White Sucker (Catostomus commersoni)
- Longnose Sucker (Catostomus catostomus)
- Shorthead Redhorse (Moxostoma macrolepidotum)
- Mountain Whitefish (Prosopium williamsoni)
- Sauger (Stizostedion canadense)
- Stonecat (Noturus flavus)
- River Carpsucker (Carpiodes carpio)
- Unidentified Chubs

This should not be considered a complete listing of species in the study area.

6.2.6 Meteorology

6.2.6.1 Climate

The climate of eastern Montana and the study area is determined to a large extent by the interaction of three major air masses with origins over the northern Pacific Ocean, the northern polar regions, and the Gulf of Mexico. The basic characteristics of these three air masses differ: the northern Pacific air is generally cool and moist; the polar air cold and dry; and the Gulf air warm and moist (Landsburg, 1969). The relative influence on the study area weather of these air masses varies with season, with Gulf air tending to dominate in summer and polar air dominating in winter. This seasonal domination of the air masses, together with the frontal activity generated by their mixing, produces the weather patterns in the study area (Missouri Basin I. A. Comm., 1969).

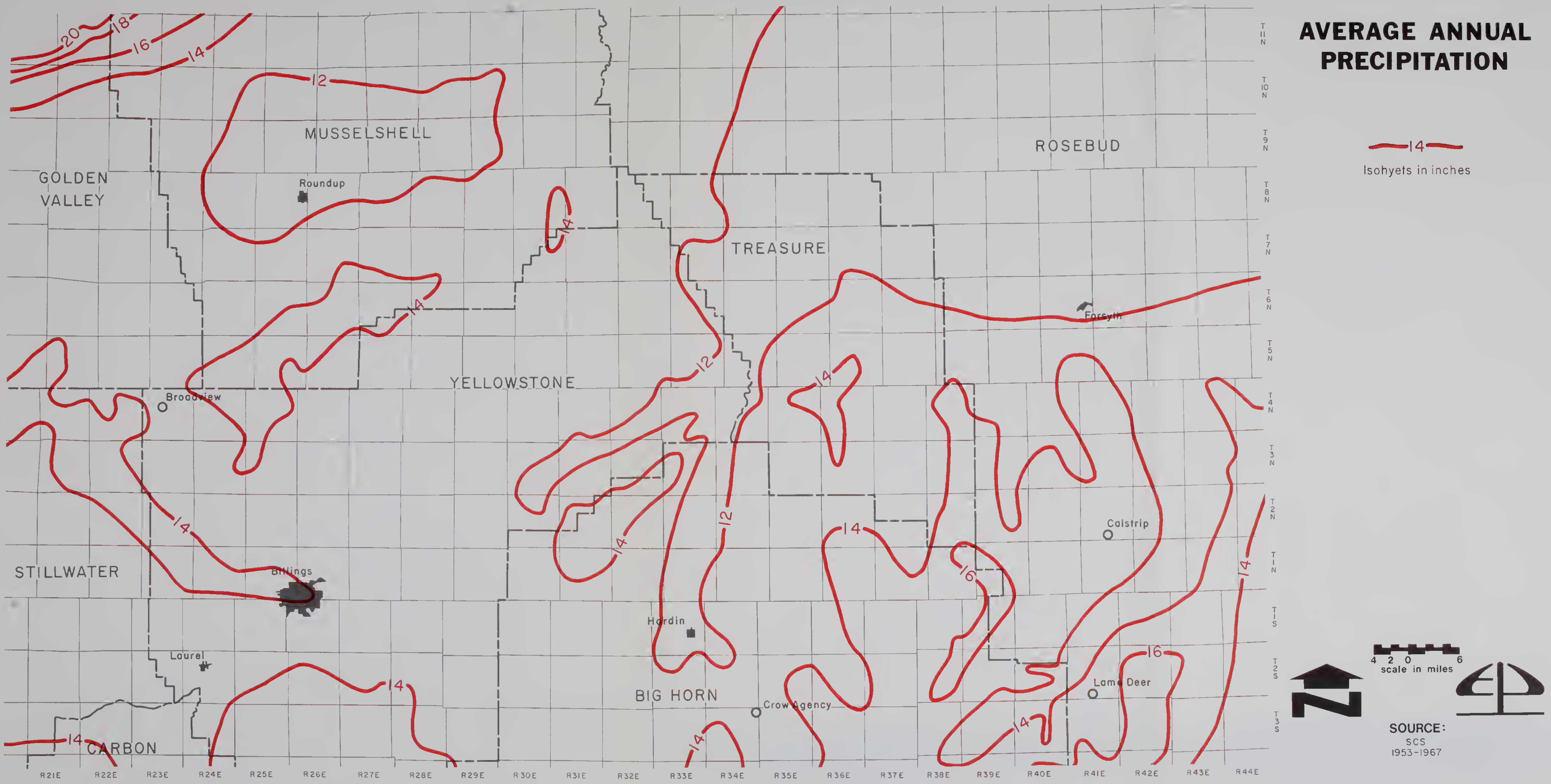
The distant location of the study area in relation to the origins of these three air masses is a factor in determining the area's climate. Air reaching eastern Montana from either the Gulf of Mexico or the northern Pacific Ocean must cross a significant land area. Pacific air must cross two mountain systems, the Cascades and the Rockies. As a consequence much of the moisture in the original air masses is lost through precipitation before reaching the study area. The temperature of the original air masses is also modified by radiation and sensible heat received from or exchanged with the ground surface.

Because of this modifying effect on the air masses reaching the study area, the area's climate reflects continental character-

istics: surface humidity is low; precipitation is high but variable, and is confined to the warmer seasons of the year; diurnal temperature variations are large and temperature extremes are pronounced; and prevailing wind speeds are moderate. The climate of the study area is therefore classified as a modified continental, semiarid type.

Winters in the study area are cold, but have few extended cold spells. The coldest periods, in which temperatures can fall well below zero, are associated with intrusions of cold Arctic air. The cold waves are initiated by moderately strong north to northeast winds and snow, with the coldest temperatures occurring on the first or second night after the snow ends and the sky clears. These cold outbreaks often end abruptly due to the onset of warmer west or southwest winds. The warmer winds can be either the warm downslope wind, the chinook, or a drainage wind of warmer Pacific origin air (U.S. Dept. Commerce, 1972). January is the coldest month of the winter with mean temperatures about 20°F. The coldest temperature recorded in the study area as of 1960 was -53° which occurred in February in Busby. Winter precipitation, for the months of December through March, normally averages less than 20% of the annual value.

Spring is a cool and wet period marked by frequent and rapid fluctuations in the weather. The months of May and June are the wettest of the year receiving over one third of the total annual precipitation. Although less likely as the season progresses, snow is possible in all spring months. The mean final occurrence of freezing temperatures in the study area varies



AVERAGE ANNUAL PRECIPITATION
14
Isohyets in inches
MUSSELSHELL
Roundup
GOLDEN VALLEY
ROSEBUD
TREASURE
Forsyth
YELLOWSTONE
Broadview
STILLWATER
Billings
Colstrip
Hardin
Laurel
BIG HORN
Crow Agency
Lame Deer
CARBON
4 2 0 6
scale in miles
SOURCE:
SCS
1953-1967
R21E
R22E
R23E
R24E
R25E
R26E
R27E
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18
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14
12

from May 15 in Billings to May 28 in Busby. The seasonal temperature change during spring is rapid. Throughout the study area the monthly mean temperatures increase over 10°F from March to April.

Summers in the study area are warm, with mean monthly temperatures in July and August in the low 70's. Mean maximum temperature in July, the warmest month of the year, is about 90°F. The highest temperature in the study area as of 1960 was 111°F in July at both Forsyth and Hysham. Precipitation in the study area for the months of July, August, and September averages from 2.56" at Broadview to 3.64" at Colstrip. These temperature and precipitation characteristics coupled with the wet spring period have helped to make agriculture viable in the arable portions of the study area.

The averages dates of the first freezing temperatures in the fall range from September 14 in Busby to September 26 in Forsyth. The mean number of freeze free days therefore varies from 109 days at Busby to 132 days at Billings with most of the study area having about 130 freeze free days.

Various tables located in Appendix C summarize the available climatic data for several stations in the study area. Table C1 contains the annual temperature and precipitation data, table C2 contains annual freeze data, and tables C3 and C4 give the monthly temperature and precipitation values. Supplementary data including humidity, wind, and thunderstorm and heavy fog occurrence was available for only one station, Billings. These data are also given in Appendix C, Table C5. The source of all of the data contained in the tables is the NOAA National Weather Service.

The climatic features most relevant to transmission line corridor selection are probably those parameters relating to line reliability such as lightning statistics; tornado and other severe wind frequencies; icing zones; and those weather effects relating to corona discharge including air density, humidity, and precipitation (G.E. Co., 1968). Data for this study area with sufficient areal coverage on which to select a corridor are available only for precipitation. As the map, "Average Annual Precipitation", indicates, the maximum annual variability is less than 8" throughout the area. This amount of variability alone is not sufficient to justify the selection of a particular corridor.

Climatic data will therefore not be considered explicitly in corridor selection. Climatic influences will be included implicitly in the evaluation of the corridor impacts on vegetation, erosion potential, wildlife habitat, and so on.

Air quality data for the study area is located in Appendix C.

6.3 Cultural Environment

The study area consists of a rectangular piece of land approximately 8 million acres in size. The total 1970 population of the area is estimated to have been about 108,000. Human activity and living patterns have been greatly influenced if not dominated, by the presence and location of the Yellowstone River and its tributaries. This influence is demonstrated in the sections which follow.

6.3.1 Land Use

Land use patterns that have emerged demonstrate the dependence of this semi-arid region on available water. It is this dependance on water that makes the Yellowstone River the main basis of spacial organization in the area.

Linear patterns show a general east - west orientation. The Burlington Northern Railroad's main line transverses the study area, almost totally following the Yellowstone valley. A second Burlington Northern line runs northwest from Billings to Great Falls, and another runs southeast into Wyoming from Huntley. A Chicago-Milwaukee line runs across the study area, leaving the Yellowstone valley at Forsyth and continuing west through Musselshell and Golden Valley counties.

Two major interstate highways service the area. Interstate 94 crosses the area along a Yellowstone valley route, and Interstate 90 enters the area at Crow Agency and runs northwest to Billings. West of Billings it follows the Yellowstone valley. Additional federal, state and county roads interlace the area.

Major electric transmission lines radiate outward from Billings. This is a result of Billings being both a major load center and a major generation site in the Montana Power Company system. Three lines run east to Colstrip and two run southeast to Yellowtail Dam. In addition, two lines run southwest, two west and three northwest from Billings. The area is crossed by additional Rural Electric Association lines and a 230 KV line running north from Yellowtail Dam to about the center of the study area and then east.

Most of the gas and oil transmission lines in the study area also radiate outward from Billings which is the major consumer of natural gas in the area and a regional oil refining center.

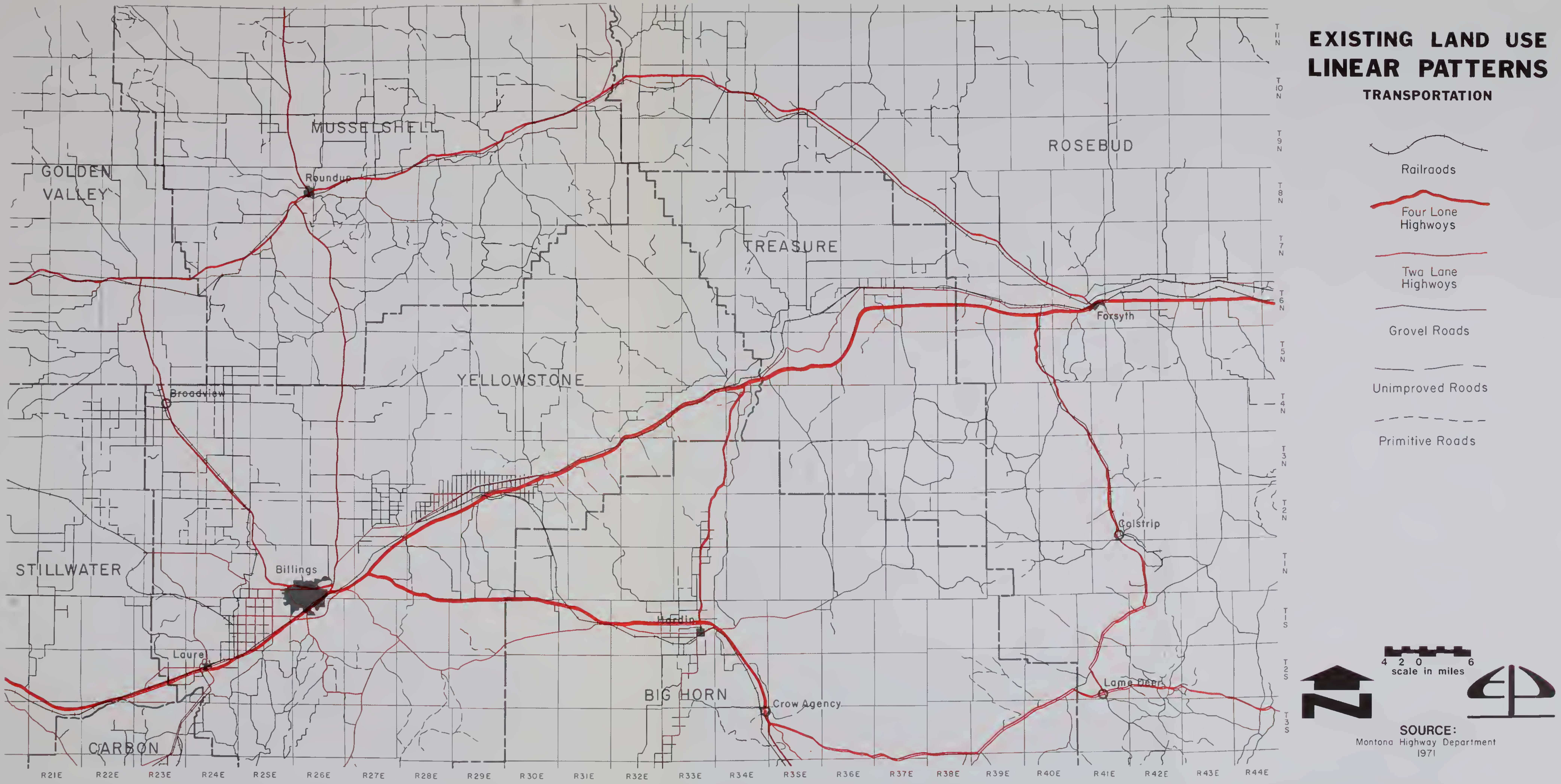
The amount of land in the study area that is devoted to urban and built up areas is very small, amounting to less than 1% of the total land area. Pasture and rangeland is the largest single land use, accounting for about 75% of the total land area. Cropland is estimated at about 10% of the area and another 7% is forest land. The approximate remaining 7% is federal land of a variety of types.

The enclosed site patterns maps portray the influence of water on human settlement patterns. The irrigated land pattern clearly traces the Yellowstone, its tributaries and the Musselshell River in the northwest corner of the study area. ~~However~~, some irrigation is also found along Sarpy and Rosebud Creeks. Dry cropland is generally concentrated in the western half of the study area.

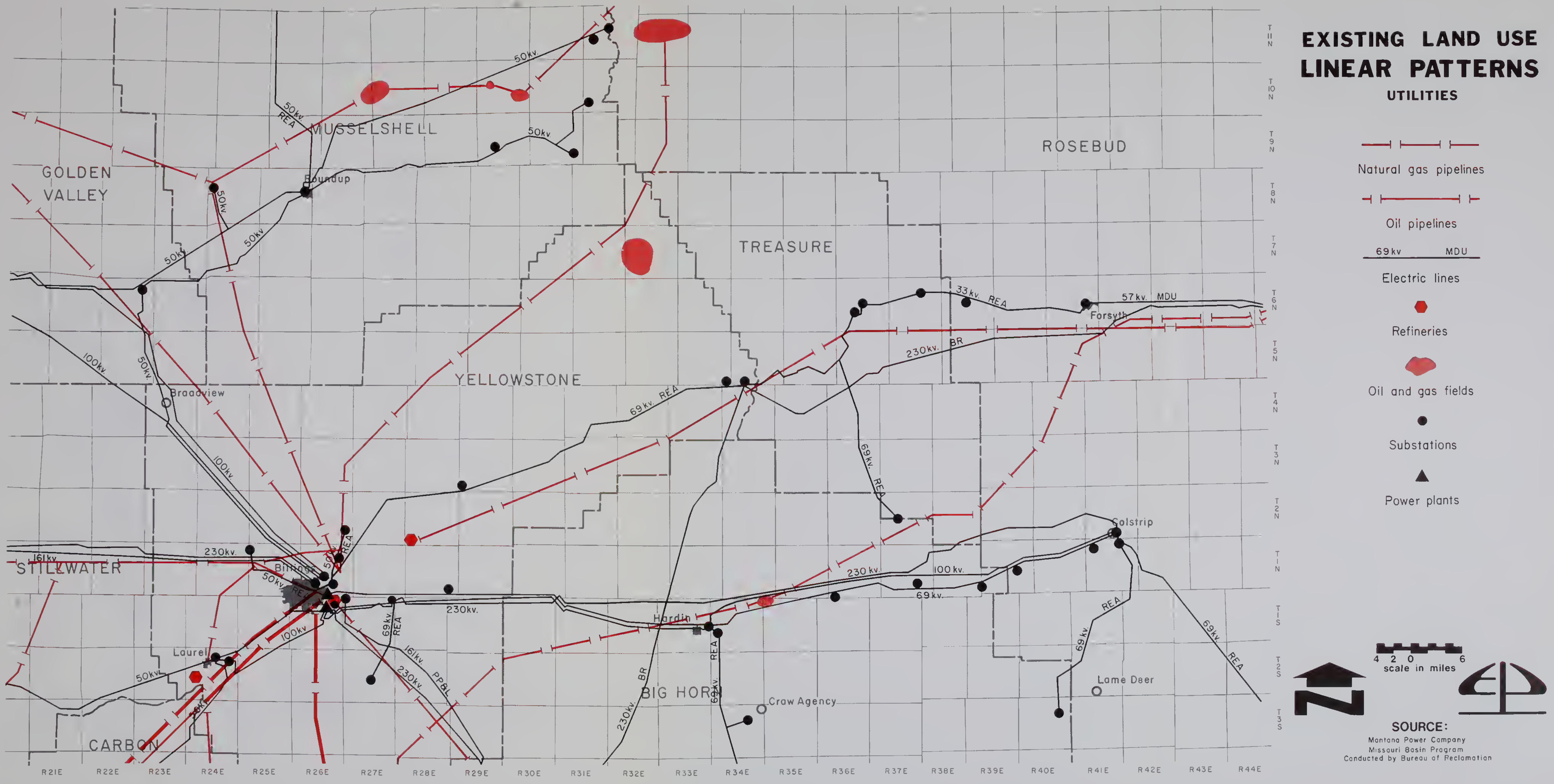
There are several different crops grown within the study area. The major ones are winter wheat, spring wheat, corn silage, corn grain, oats, barley, sugarbeets, and hay. Average yields for both irrigated and non-irrigated cropland are summarized as follows (Mont. Crop Reporting Service, 1972). Winter and spring wheat yields for irrigated land are 42 and 29 bushels per acre, respectively and 42 and 24 bushels per acre for non-irrigated land. Yields in bushels per acre of oats and barley on irrigated land are 63 and 37 bushels, respectively, and 51 and 40 bushels per acre for non-irrigated land. Corn grain yields are around 73 bushels per

EXISTING LAND USE LINEAR PATTERNS

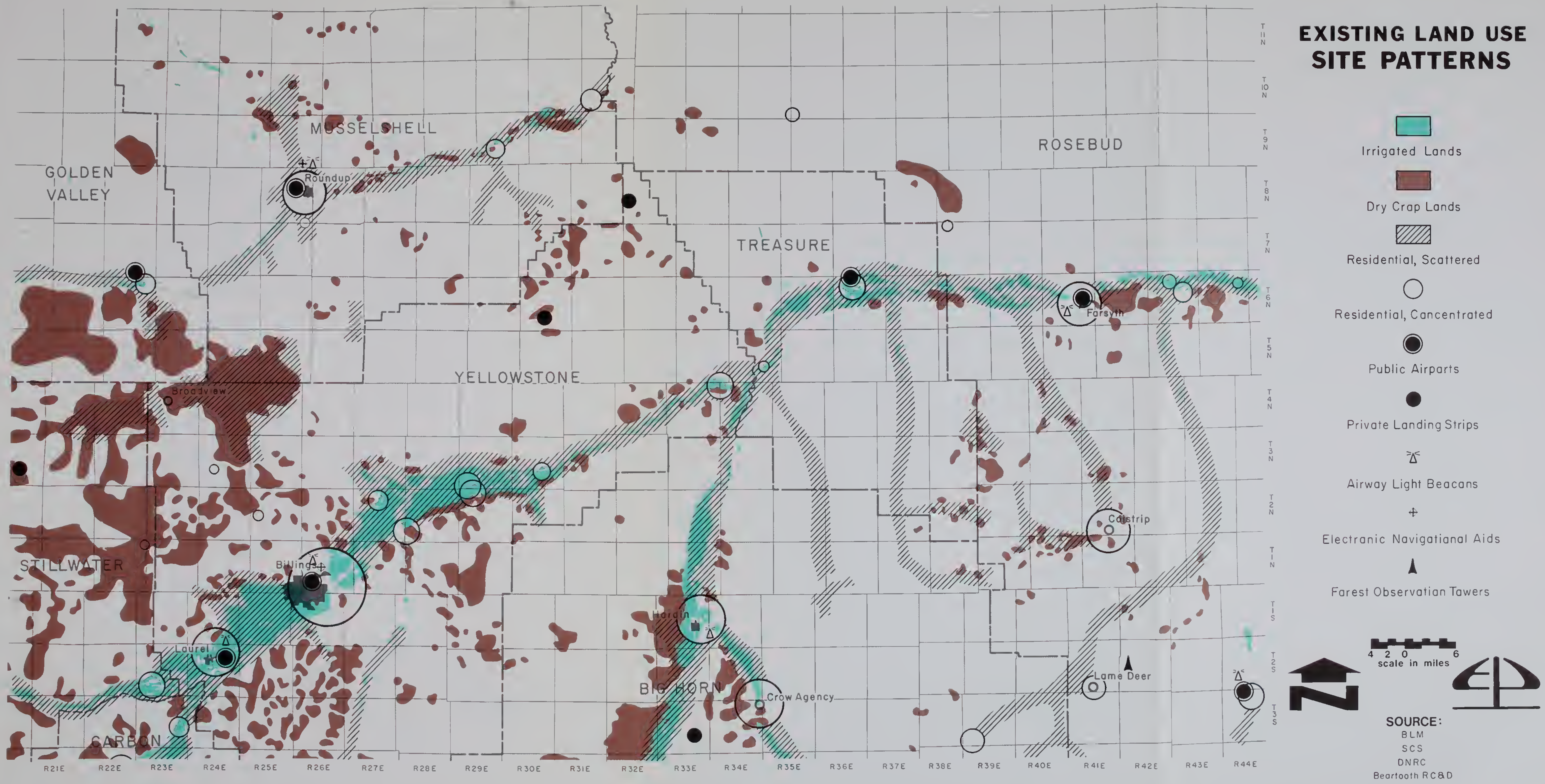
TRANSPORTATION



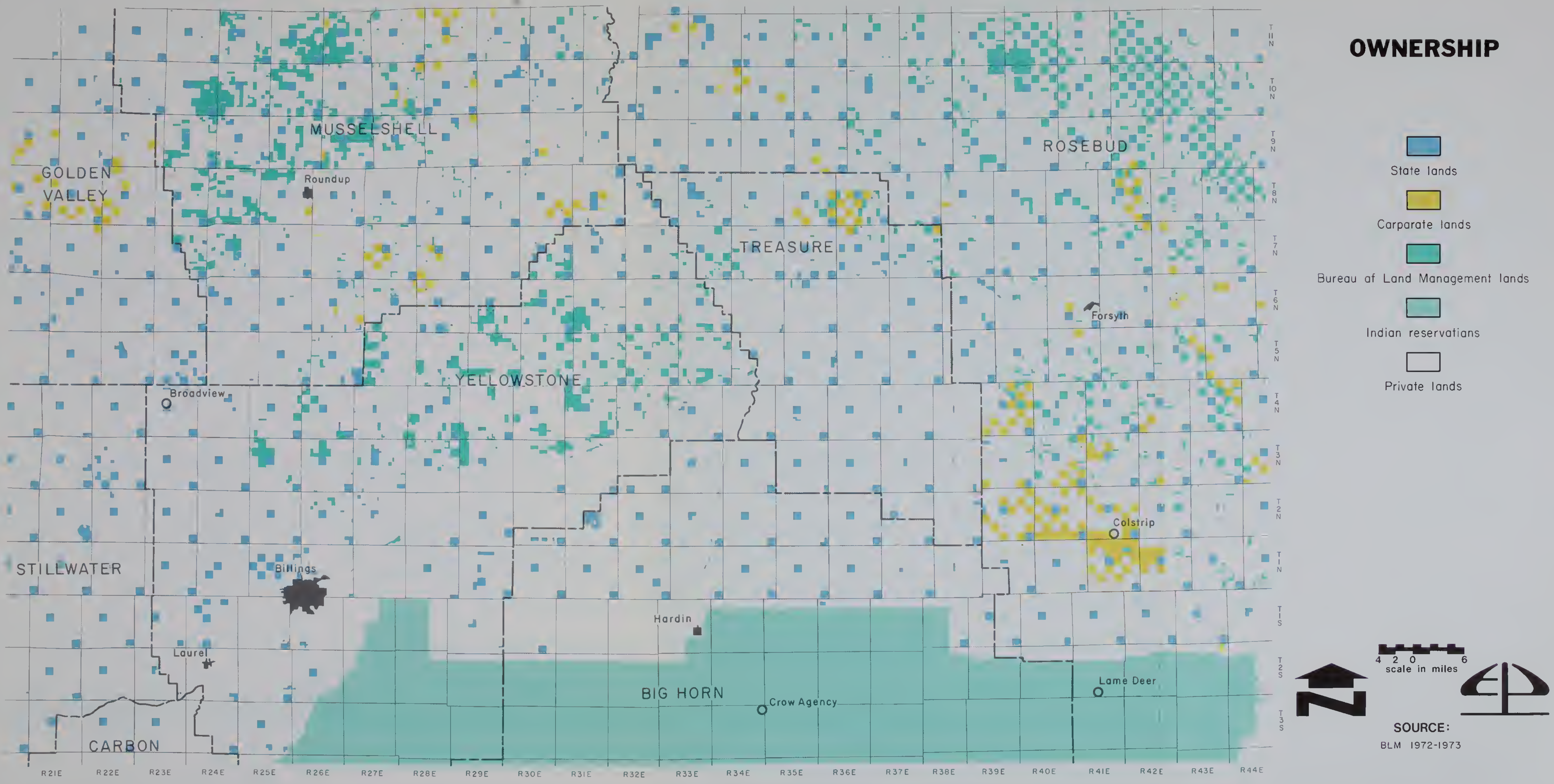
SOURCE:
Montona Highway Department
1971


EXISTING LAND USE
LINEAR PATTERNS
UTILITIES
Natural gas pipelines
Oil pipelines
69 kv MDU
Electric lines
Refineries
Oil and gas fields
Substations
Power plants
4 2 0 6
scale in miles
SOURCE:
Montana Power Company
Missouri Basin Program
Conducted by Bureau of Reclamation
MUSSELSHELL
GOLDEN VALLEY
ROSEBUD
TREASURE
YELLOWSTONE
STILLWATER
CARBON
BIG HORN
Roundup
Broadview
Billings
Laurel
Forsyth
Colstrip
Hardin
Crow Agency
Lame Deer
50kv.
50kv REA
100kv.
230kv.
161kv.
69kv. REA
33kv. REA
57kv. MDU
230kv. BR
100kv.
69kv.
230 kv.
161kv. PP&L
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S

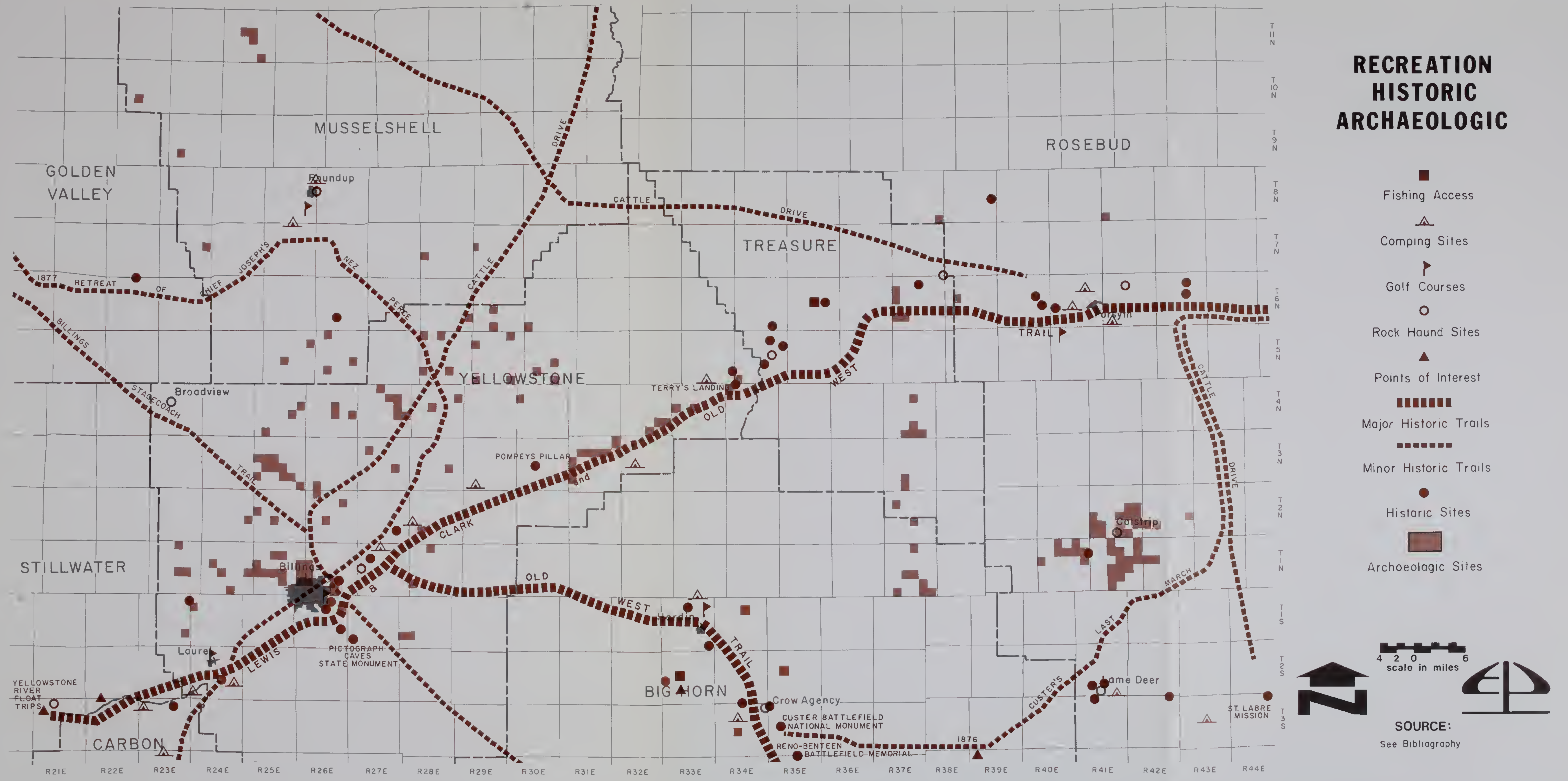
EXISTING LAND USE SITE PATTERNS



OWNERSHIP



SOURCE:
BLM 1972-1973



RECREATION
HISTORIC
ARCHAEOLOGIC
Fishing Access
Comping Sites
Golf Courses
Rock Haund Sites
Points of Interest
Major Historic Trails
Minor Historic Trails
Historic Sites
Archaeologic Sites
4 2 0 6
scale in miles
SOURCE:
See Bibliography
MUSSELSHELL
GOLDEN VALLEY
ROSEBUD
TREASURE
YELLOWSTONE
STILLWATER
CARBON
BIG HORN
Roundup
Broadview
Billings
Laurel
Hardin
Colstrip
Lame Deer
Crow Agency
TERRY'S LANDING
POMPEYS PILLAR
PICTOGRAPH CAVES STATE MONUMENT
CUSTER BATTLEFIELD NATIONAL MONUMENT
RENO-BENTEEN BATTLEFIELD MEMORIAL
ST. LABRE MISSION
YELLOWSTONE RIVER FLOAT TRIPS
1877 RETREAT OF CHIEF JOSEPHS
NEZ PERCE
CATTLE DRIVE
BILLINGS STAGECOACH TRAIL
LEWIS and CLARK
OLD WEST TRAIL
CUSTER'S LAST MARCH
1876
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S

acre on irrigated land. Corn silage yields on irrigated land are 17 tons per acre and 4 tons per acre on non-irrigated land, and hay production runs 3 tons per acre on irrigated land. On non-irrigated land average hay yields are from 1 to 1.5 tons per acre.

Land ownership is broken down into Indian reservations, Bureau of Land Management (BLM) lands, state lands, corporate lands, and private lands on the accompanying ownership map. There are two Indian reservations, the Crow and Northern Cheyenne, lying across southern Yellowstone, Bighorn and Rosebud counties.

Northern Cheyenne Reservation land falling within the study are totals approximately 353,000 acres. There are about 875,000 acres of Crow Reservation land in the study area. BLM land in the area totals about 333,000 acres and is mostly confined to the northern portions of Musselshell, Yellowstone and Rosebud counties. Corporate land, consisting almost exclusively of Burlington Northern Railroad holdings, totals about 12,000 acres, with the major concentration being in Rosebud County, particularly around Colstrip. State land ownership, about 350,000 acres, is quite uniformly spread over the study area. The remaining category, private lands, dominates the ownership pattern with about 5,967,000 acres being so held. Private land is spread over the entire study area excepting the area encompassed by the Crow and the Northern Cheyenne Reservations. The dominance of private land is particularly noticeable along the Yellowstone River.

Compared to nearby areas west and south of the study area, water based recreation is limited in the study area. There are no major lakes in the area, but the Yellowstone is a popular

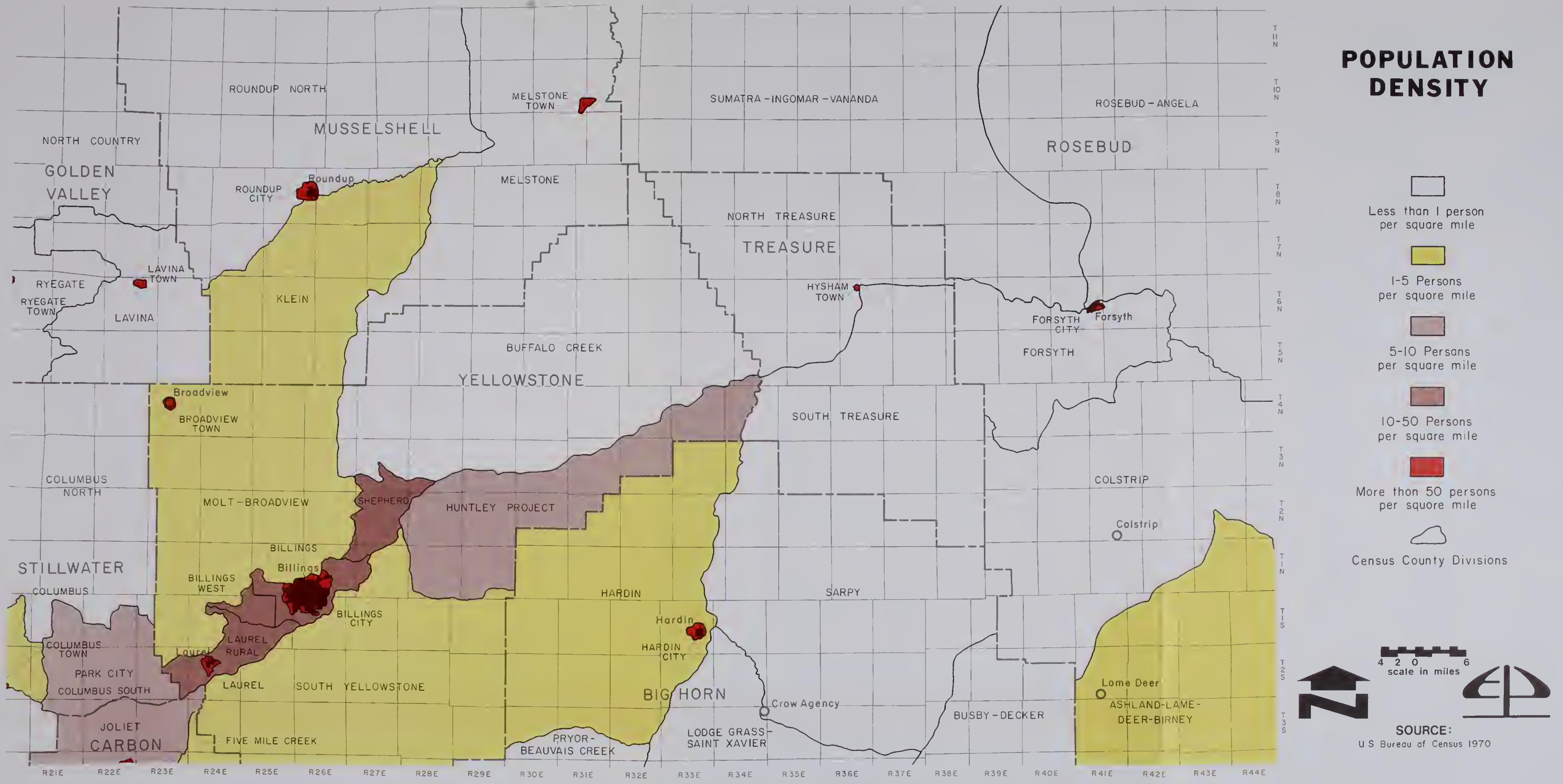
float trip stream. The Yellowstone and Bighorn Rivers and other smaller streams in the area provide fishing opportunities for trout, sauger, walleye pike, catfish, ling and sturgeon. The Yellowstone is particularly noted for its paddlefish population.

Hunting is found over most of the study area. Game animals range from the big game species of deer and antelope to small game such as turkey, sharp-tail and sage grouse, pheasant and Hungarian and chucker partridge. There is also duck and goose hunting along the Yellowstone valley. Rock hounding is a popular activity in much of the area.

Major historic sites, trails, and known archaeological sites are shown on the "Recreation/Historic/Archaeologic" map The historic sites of the region include early forts such as Fort Manuel Lisa, Fort Alexander, and Fort Sarpy; trading posts such as the Fox-Livingston and Company Post; Indian battlefields, including Custer's Battlefield National Monument and the Reno-Benteen Battlefield Memorial; and various camp sites of the Lewis and Clark Expedition. The most famous of the historic trails in the region is the return route taken by Captain Clark down the Yellowstone in 1806. Although much of the area has not been surveyed archaeologically, many sites have been located and are indicated on the map. These sites may reveal more about the location of past investigations than about the total distribution of sites in the study area.

6.3.2 Population

The study area consists of eight counties. Yellowstone,


POPULATION DENSITY
Less than 1 person per square mile
1-5 Persons per square mile
5-10 Persons per square mile
10-50 Persons per square mile
More than 50 persons per square mile
Census County Divisions
4 2 0 6
scale in miles
SOURCE:
U S Bureau of Census 1970
ROUNDUP NORTH
MUSSELSHELL
MELSTONE TOWN
SUMATRA-INGOMAR-VANANDA
ROSEBUD-ANGELA
ROSEBUD
NORTH COUNTRY
GOLDEN VALLEY
ROUNDUP CITY
Roundup
MELSTONE
NORTH TREASURE
TREASURE
RYEGATE
RYEGATE TOWN
LAVINA TOWN
LAVINA
KLEIN
HYSHAM TOWN
FORSYTH CITY
Forsyth
FORSYTH
BUFFALO CREEK
YELLOWSTONE
Broadview
BROADVIEW TOWN
SOUTH TREASURE
COLUMBUS NORTH
MOLT-BROADVIEW
SHEPHERD
HUNTLEY PROJECT
COLSTRIP
Colstrip
BILLINGS
Billings
STILLWATER
COLUMBUS
BILLINGS WEST
BILLINGS CITY
HARDIN
SARPY
Hardin
HARDIN CITY
COLUMBUS TOWN
Laurel
LAUREL RURAL
PARK CITY
COLUMBUS SOUTH
LAUREL
SOUTH YELLOWSTONE
BIG HORN
Crow Agency
Lame Deer
ASHLAND-LAME-DEER-BIRNEY
BUSBY-DECKER
JOLIET
CARBON
FIVE MILE CREEK
PRYOR-BEAUVAIS CREEK
LODGE GRASS-SAINT XAVIER
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S

Treasure and Musselshell counties lie completely within the study area, whereas Bighorn, Custer, Golden Valley, Rosebud and Stillwater counties extend beyond the boundaries of the study area. Total population for the eight counties was 120,902 in 1970 and 116,489 in 1960. Only Yellowstone County showed a noticeable increase over the ten year period. Bighorn County was essentially stable and the six remaining counties showed a decrease in population. The only substantial increase in population over the 1960 to 1970 period was in the Billings area; the Billings population subdivision of Yellowstone County grew from 52,900 to 74,848.

For the study area only, total population is estimated to have been approximately 108,000 in 1970. Based on an estimated 8,000,000 acre land area, average population density is slightly over 8.6 people per square mile. Densities range from several thousand per square mile in the city of Billings to less than one per square mile over most of the study area.

The population map shows population densities based on 1970 census data for county population subdivisions. The prominance of population in the Yellowstone valley in general, and the Billings area in particular, shows up clearly.

6.3.3 Social Aspects

As was noted in the previous section, the major part of the study area is sparsely populated with long distances between towns. The area is predominantly agricultural, and thus the local living style is dependent on such factors as varying amounts of rainfall and fluctuating agricultural market prices in any given

year. This combination is partially responsible for the reselient and independent characteristics of the people in the area. The agricultural life style also fosters strong ties with the land and a basic identification with the nature cycles. Even the regional speech patterns reflect a close adherence to the land and visual appreciation of it.

Entertainment is more of an active, "do-it-yourself" phenomenon than the passive, paid-for entertainment of urban areas. Commercial entertainment is largely lacking as are many specialized occupations that demand higher population density to be economically viable.

Billings is the comercial, industrial, transportation and cultural center of the area. Due to greater population size more varied life styles, more specialized skills and more diverse enterprises are sustainable there than in the rural areas.

6.3.4 Economic Aspects

Historically, the economic base of the study area has been agriculture, with the livestock industry as the foundation. The crops grown are mostly grains, sugar beets and hay. Billings has emerged as the wholesale and retail center of the area in addition to supporting a growing oil refining industry and meat packing operations. Oil and natural gas fields are scattered north of the Yellowstone River and coal may become increasingly important in the eastern part of the study area.

The following table gives an idea of the level of economic activity in the study area (IGR, 1970).

County	Year 1968	
	Total Personal Income ($ millions)	Per Capita Personal Income
Bighorn	22.7	1932
Custer	16.3	2156
Golden Valley	3.0	2301
Musselshell	10.0	2718
Rosebud	17.6	2810
Stillwater	12.6	2690
Treasure	3.7	2091
Yellowstone	271.6	3323

7. Impact Analysis

The following impact analyses consist of 1) a search of existing literature to ascertain possible theoretical impacts of construction, operation and maintenance of a transmission line on the environment; and 2) comments on the impacts which may occur in the specific study area considered in this report. All analyses will examine both the constraints imposed upon the environment by the proposed facilities and the constraints imposed upon the facilities by the environment. The envelope attached at the end of this report contains a transparent map overlay which shows the preferred transmission line route and alternate routes proposed by the applicant, and the preliminary corridor route selected by the DNRC. This overlay can be superimposed on each map to compare corridor locations with the natural and cultural features in the study area.

7.1 Natural Environment

7.1.1 Geology

Geologic setting or circumstances affect engineering, mainteinance, and reliability of transmission lines, towers, and tower footings. Although most problems can often be countered locally by superior and probably more expensive design, construction, and maintenance practices, certain terrains can occasionally be avoided where it is more practical. It is important to note that geologic constraints can affect the performance of utility facilities.

Purposeful avoidance of practices and terrains which would cause undesirable geologic impacts effectively constitutes a

separate category of geologic constraints on transmission lines. Effects of the construction on geology, where unprevented, include changes in kind or rate of geologic processes, actual changes in physical geologic features, and changes in human access to such features. Potential geologic impacts are discussed below under three categories:

1. Electrical effects of the lines
2. Physical presence of the lines and towers
3. Construction requirements and practices

Electrical Effects

Soil and other geologic materials contain clay, a material which is unique in its large capacity to absorb ions and water molecules onto the surfaces of individual clay particles. Weak electrostatic attraction among these ions, water molecules and other clay particles plays a large part in determining the physical properties of geologic material. Electromagnetic fields surrounding A.C. power lines cause varying degrees of electrical induction in all nearby charged particles. If inductive redistribution of ions occurs in soil and regolith, the soil structure, slope stability, soil moisture chemistry, and ground water quality may conceivably be affected. However, apparently no available literature provides information on these effects, although research is continuing in this area.

Effects of Physical Presence of Structures

The physical presence of transmission lines interferes with exploitation of geologic resources. The only earth resources known

to be of significance in the Colstrip-Broadview study area are coal, clay, and groundwater. Clay and groundwater are of sufficiently widespread occurrence that the amount of land precluded from exploitation by the presence of the transmission towers and lines is insignificant.

Coal, although also widespread, represents far greater value. It seems probable that the cost of relocating portions of a transmission line in order to mine underlying coal may generally be offset by the profits to be gained from the coal. Locally, however, small areas of strippable coal may be rendered marginal or uneconomical if mining them necessitates transmission line relocation. An additional potential consequence of the physical presence of transmission structures concerns slope stability. Overloading of inherently weak slopes may induce hillslope failure. The obvious result includes loss of the line as well as any of the potential consequences commonly associated with landslides and rockfalls.

Effects of Construction

The most widespread and common consequences of transmission line construction fall under the category of "man as a geologic agent." These result from man's role as an earth mover. Specific examples of these effects include:

1. Soil loss due to road building, site preparation, and vehicular traffic
2. Reshaping and scarring of landscapes
3. Intersection of the groundwater table and diversion of groundwater to overland flow
4. Channelization or ponding of surface waters

5. Direct or indirect alteration of streams
6. Destruction or defacement of geologic features of scenic or scientific interest
7. Disturbance of metastable slopes

These geologic effects may generally be considered undesirable -- their degree of acceptability depending on their relative permanence and areal extent. Only soil loss and reshaping of the landscape are inevitable. Surface diversion of groundwater may be unpredictable and is an unusual, primarily local problem. The effects can be avoided through proper construction practices and precautions. The potential for all undesirable effects can be minimized or eliminated by adherence to terrain that requires the least excavation.

Inasmuch as the major adverse geologic impact of power line construction arises from road building and site preparation, the presence of existing secondary and unimproved roads, and ease of off-road access are significant geologic considerations.

Road construction and site preparation require the greatest excavation and cause the greatest soil loss when undertaken on steep slopes. Road building ordinarily involves cut and fill. The total amount of soil area removed by cutting and buried by fill often greatly exceeds the width of the road surface. For a given road surface width, the steeper the terrain, the wider the area of soil that is affected. Additionally, terrain that necessitates sharp bends in access roads (i.e., gullies, sharp plunging ridges, and switchbacks) requires significant excavation for passage of large equipment and should be avoided.

Specific guidelines that will minimize geologic impacts include:

1. Restriction of access roads to the most level ground practicable, even if this requires significant departures from the 300 foot right-of-way and especially if this reduces the total surface area that is affected.
2. Location of tower sites so that the above guideline may be accomplished.
3. Good road construction practices so that water is neither ponded nor channeled; and excavation of road cuts to a stable angle of slope for the materials involved.
4. Reclamation of all excavated sites or trails, with the same attention given to revegetation as that required under the Strip Mining and Reclamation Act, including replenishment of topsoil.
5. Avoidance of certain inherently unfavorable terrains that are frequently local in extent. These include local shale badlands along Sarpy Creek, where excavation is likely to aggravate existing rapid erosion, preclude effective restoration, and make maintainence of access roads a continuous problem. Also included are areas of clinker. Restoration of excavated clinker may be nearly impossible, even with replacement of topsoil, due to the very high permeability of the disturbed rock.

Physiography

Physiography plays an important role in the selection of a transmission line corridor. Whether the criteria for selecting a corridor emphasizes ease of access, land use patterns, or population densities, physiography has an influence, even though it may be indirect in some cases.

The physiographic units described in Chapter 6 and shown on the physiographic map are areas having different kinds and degrees of impacts. Brief statements concerning the kinds of impacts for each unit follow.

MDL and MDL-T

This unit is characterized by steep slopes and rather great local reliefe (over 1,000'). Building a transmission line through this kind of area would involve lengthy access roads requiring a great deal of cut and fill. Erosion of the disturbed land would tend to be difficult to control or avoid.

DL and DL-T

Although the local relief in this unit is less than in the previous unit, the kinds of impacts are the same. A given line traversing a given route through this kind of terrain may have minimal impact if local circumstances are favorable. Otherwise, access to the tower sites would present numerous problems.

PL and PL-T

Slopes and relief are smaller in these units than in the

previous ones. Although access roads could be built with less impact in this terrain, the unit contains some dry-land and irrigated cropping. From a geologic point of view, this unit would generally be favorable for transmission lines.

UL

Within this unit, slopes are rather slight and access is generally no problem. The areas designated UL are often high and bordered by steep terrain. These areas are generally in crop lands.

HS

Impacts in these areas depend partly upon the direction of the transmission line. If the line parallels the "grain" or trend of the landforms, impacts of access, land use conflicts, and aesthetics may all be minor. However, if the line crossed the linear features, severe impacts may result.

LS

Because the relief in this unit is smaller than the previous one, the impacts would tend to be less severe under worst conditions, but the kind of impacts would be the same.

BL

Access to the line would be difficult in this unit because of numerous steep slopes and erosion potential. Even if a road were built in this kind of terrain, it could not be expected to survive for long periods of time.

CL

Although access could be difficult locally and would require some road building, the narrow width of these units limits the severity of any impacts.

DT

Except in crossing some gullies in this kind of terrain, access should be easy and would have little impact. Some dry cropland does occur within the unit.

V

The valleys are generally quite level and many existing roads provide access within these areas. Where existing roads cannot be used, there is little need for cut and fill construction. However, the valleys contain the best agricultural land (much of it irrigated) and most of the people. Likewise, the valleys contain the streams and their floodplains. Geologically, the valleys are good places to build transmission lines, if kept out of the floodplains. However, impacts upon other resources in the valleys generally outweigh the geologic advantages.

7.1.2 Hydrology

Many potential hydrologic impacts that may be either created or intensified by a transmission line are local in nature,

but minor adjustments in the route of the line or access roads will avoid most of these. Therefore, when choosing a corridor, two kinds of hydrologic impact areas should be considered: first, areas where a large number of local problems exist, and second, where a large continuous feature exists such as a large lake or river.

Specific wells or springs can be avoided by proper centerline selection even though the feature lies within a selected corridor. Springs and wells become important in corridor selection only if they occur in numbers, possibly with other types of features, so that it becomes difficult to select a suitable centerline. In such cases, the area should be avoided by the corridor.

Large lakes and rivers may be larger than the corridor and therefore impossible to avoid by adjustments to the centerline. Thus corridor selection must take such features and the resulting impacts into account if the features themselves cannot be avoided.

Within the study area, two types of hydrologic features are of concern in corridor selection. These are the larger streams and the ephemeral lakes in the western basins. The crossing of the streams involves the stream channel and the floodplains. A corridor which crosses the floodplain at the narrowest point would expose the shortest length of the line to flood hazards and other impacts on or by the river. However, other considerations may preclude crossing at these points.

Marshy basins, ephemeral lakes, and lake beds present access problems during construction and maintenance. The resultant rutting and disturbance of the vegetation by vehicles in wet weather could seriously interfere with other land uses. Also, the lake bed sediments tend to make poor foundations.

7.1.3 Soil

The impacts of transmission lines on the soil resource occur in four broad catagories:

1. operation of the line
2. construction of the tower foundations
3. construction of roads and staging areas
4. permanent use of access and maintenance roads.

Further discussion of these categories follows.

Operational Impact

The operational impact of the line (i.e., the impact of the electrical characteristics) upon soil is not known at this time (DNRC, Soil Group Workshop, 1974). However, some possible interactions are:

a. Effects on the soil molecular system, e.g., nutrient exchange properties and clay properties
b. Effects on the soil's micro-organisms
c. Changes in chemical properties, e.g., nitrogen fixation
d. Effects of noxious gases, if any, on erosion control plantings
e. Effects on the soil-water regime and its implications for erosion control plantings

Further research on operating transmission lines must be conducted in order to make any definite statements on these potential impacts.

Tower Foundation Construction

The impact of tower foundations and their construction is two-fold: 1) Soil stability may affect or be affected by the tower foundation and 2) possible erosion may result from construction. The erosion impact will be discussed in the section on road and staging area construction. Soil stability is the major area of interaction between the soil resource and any foundation structure. Factors affecting the stability of the soil, such as slope, depth to bedrock, and drainage, are significant where they generate limitations due to mass failure hazard or the presence of clay soils with high shrink/swell potential. Limitations also result if freezing soil temperatures and high water table interact to produce frost heaving. One further factor affecting tower foundation construction related to soils or surface properties is the occurrence of hard, massive rock at or near the surface. Constraints such as these can be overcome or mitigated by careful site selection and tower placement, but varying amounts of cost and effort are required.

Construction Of Roads And Staging Areas

Construction of maintenance and access roads and staging areas will cause the greatest amount of soil to be disturbed and will result in the largest degree of erosion hazard. However, careful location of the roadways will minimize this potential impact. For instance, if roads are cut on contours and proper drainage is

constructed based on terrain and season of consturction, long term erosion of the soil will be minimized. If, on the other hand, roads are layed out on the premise that "the straight line is the shortest distance," then erosion of the soil will be a continuing problem (Packer, 1967).

Erosion generally has two major effects: 1) fertile top soil is lost and thereby the productivity of the immediate construction area declines; and 2) the soil which is eroded may become a sedimentary pollutant of downslope surface waters. The probability of sedimentation is a function of the soil's inherent erosion hazard, the proximity of the soil disturbance to surface drainage channels, slope gradient and slope length, and the length of time the soil remains bare of protective vegetative cover. The long-term risks can be mitigated by practices such as reseeding, drainage, and location procedures which avoid erosive soils and surface drainage channels; however, the short-term risks during construction and shortly thereafter are largely unavoidable (Holdorf, 1974; Kitchings, et al., 1974; Donahue and Ashley, 1973; and Schumm and Hadley, 1961).

Vegetative cover, as suggested above, is a stabilizer of erosion hazard. In gently sloping areas where cutting and filling is not needed for temporary road construction, an attempt will be made to preserve the existing low-level vegetation. Whether or not this can be done will depend upon traffic intensities and soil conditions during periods of use. Some roads will be needed only

during construction and then will be drained, seeded, and closed to traffic after construction is completed.

All roads across sloping land will require cut and fill construction. This destroys existing vegetation (Holdorf, 1974; Packer, 1967) and creates some of the same potential problems discussed in Section 7.1.4.1 regarding the removal of existing vegetation in the transmission corridor. If an area is reseeded with native vegetation species, negative effects may be kept to a minimum. However, if a construction area or right-of-way is reseeded with vegetative cover other than what is endemic to the area, changes in soil fertility and nutrient uptake may result. A further consideration is the movement of herbicides through the soil if they are used to maintain exotic or seral vegetation within the corridor or construction area. There may also be possible effects on the soil water regime.

Permanent Use Of Access And Maintenance Roads

The impact of the permanent use of access and maintenance roads is generally the same as for their construction with one addition, trafficability of the soil. Traffic disturbance compacts the surface soil horizons, greatly reducing the soil's natural infiltration rates and permeability and generally weakening and destroying the soil's structural aggregates. With this type of disturbance the soil erosion hazard is largely a function of the gravel and stone content of exposed horizons. The higher the percentage of material resistant to detachment and movement, the lower the hazard. The erosion hazard for compacted soils,

therefore, differs from that for cultivated soils in that soil properties such as structural aggregate stability, water holding capacity, and permeability are reduced to a common level by the compaction; and climatic factors become unimportant because almost all precipitation yields runoff due to the lowered soil permeability.

An unspecified mileage of roads will be needed permanently for access and/or maintenance. These obviously should be drained and stabilized as much as possible.

It may be observed from the "Soil Erosion Hazards" map that erosion hazards and sedimentation risk will be moderate to severe in large portions of the study area. The soils of much of the study area overlay the Fort Union formation of interbedded unconsolidated and consolidated sedimentary rocks. These well dissected uplands have sufficient relief to require extensive cut and fill road construction. The precipitation of the area is generally low, and may be in the form of short, severe thunderstorms with effective available vegetation moisture even lower than that suggested by average precipitation figures. This presents definite limitations on revegetation potential. The combination of these factors is high sediment risk (i.e., cut and fill road construction exposing highly erodable bedrock, low success in reestablishing vegetation on slopes, and dense drainage patterns resulting in sediment movement into higher order streams).

The remaining portion of the study area can generally be rated slight in erosion potential and sedimentation risk. These areas consist of soils on the alluvial valley floors of larger streams and old terraces and erosional surfaces along the Yellowstone River. They are characterized by level to gently sloping undissected surfaces, often with high percentages of coarse fragments in the upper profile that resist detachment and movement.

7.1.4 Vegetation

7.1.4.1 Vegetation Removal

The removal of vegetation from transmission line right-of-way corridors and access roads cannot be avoided in many instances, such as forested areas and areas of high brush. In order to determine the intensity of the impacts of removal, the method or methods used are very important. The discussion here will be limited only to general impacts arising from vegetation removal.

During construction phases of a transmission line some of the first order impacts are accellerated erosion, nutrient loss, and loss of biomass production (Kitchings, et al., 1974).

On range or cropland the impacts are not too severe. However, they can be very important. For example, in a rangeland community a limited amount of clearing is necessary, mostly at tower locations and access roads. With time and good follow up procedures of revegetation, the rangeland production could return to or near to its original state. On cropland the heaviest impact would also be a short term loss in production. However, even a short term loss is very significant to the owner because many farmers and ranchers operate on a small margin of profit. The decrease in potential production could determine whether or not any profit would be realized from that crop.

In forested areas, impacts of transmission lines are far greater environmentally than on range or cropland. Forested areas, in general, are more diverse communities in that there is more life form variability than one would find in rangeland communities. Once a right-of-way has been cleared through a forested area, the forest biomass cleared from that right-of-way is forever lost whereas a grassland is permitted to restablish on the right-of-way.

Right-of-ways and/or access roads are certain to cross or parallel water courses at some point. The impacts of such action on the water course, due to the removal of riparian vegetation, can be very severe. With removal of stream bank vegetation the stability of the stream bank is lost, and, consequently, water quality is decreased due to erosion of the banks by the stream. In many cases this process can result in losses of large portions of land.

7.1.4.2 Associated Impacts of Vegetation Removal

Nutrient losses will occur in conjunction with erosion. Water, the prime agent of erosion, leaches out the nutrients that are released due to the removal of vegetation and carries them out of the area. Possible destinations of these nutrients would be streams, rivers, ponds, and lakes where they are made available for aquatic vegetation, ultimately resulting in eutrophication activity.

Revegetation Problems

The primary objective in relation to revegetation on a transmission line right-of-way is to have a stabilized low growing plant community. However, this is very difficult to achieve in that the original vegetation of any particular area would make up a stabilized community but not necessarily a low growing community. Some method of cutting back the vegetation would have to be employed periodically to achieve a low growing community over extended periods of time in

forested areas. Herbicides are often used for the purpose of suppressing the vegetation, but this produces subsequent associated impacts on the environment. With the use of herbicides, in addition to clear cutting, nutrient losses are accellerated (Bormann, et al., 1968). Under such a system of cutting and subsequent suppression, available nutrients are also lost by increasing the amount of water passing through the system and thus reducing the ecosystem's ability to extract nutrients from the leaching water (Kitchings et al., 1974). If herbicides are not used and successional stage species are allowed to grow and develop, nutrient losses can be minimized by:

> 1. channelling of water from runoff to evapotranspiration, thereby reducing erosion and nutrient loss; 2. reduction in rates of decomposition through moderation of the microclimate during the growing season, so that the supply of soluble ions available for loss in drainage water is reduced; and 3. simultaneous incorporation into the rapidly developing biomass (of successional vegetation) of nutrients that do become available and that otherwise might be lost from the system. (Marks and Bormann, 1972)

Some other associated impacts of herbicide use are drift of spray or volatile fumes via air currents from the target areas to adjacent crops or woodlands and surface as well as underground water courses (Westlake and Gunther, 1966). Rainfall can also act as an agent of transportation of herbicides to areas remote from the site of application (Cohen and Pinkerton, 1966). Direction, distance, and amount of drift are influenced by droplet size, direction and velocity of wind, and the type of spray used (Anon., 1968).

Introduced Species

Due to the fact that revegetation of right-of-way corridors to existing vegetation communities is difficult and often impossible, a monoculture or single species population is often established on the right-of-way. Without species diversity, wildlife habitat is reduced, and the population could be subjected to wide-spread disaster such as insect infestations. A Christmas tree plantation is an example of a monoculture that could be established in a forest area, whereas in rangeland a pure stand of crested wheat grass (*Agropyron desertorum*) could be used. In simplified or monotypic communities the use of chemical insecticides is necessary to control insects, especially those attracted to such a situation, because natural predators are usually destroyed by a monoculture situation (Kitchings, et al., 1974).

Insecticides can be transported from target to non-target terrestrial and acquatic communities in the same ways that were discussed for herbicides. Some insecticides are very persistent and consequently are subject to biological magnification through food chains. This poses a hazard to all wildlife species, especially those which are members at higher trophic levels such as raptorial birds and other predators (Rudd, 1964).

Revegetation of right-of-ways and roads after construction of transmission lines should be restricted to native vegetation wherever possible. The use of introduced species could have possible impacts. Introduced species are often very hardy and able to adapt to a wide variety of ecological conditions. For this reason introduced species are very competitive with natural

species and are, in many instances, capable of moving out of the corridor and replacing natural vegetation. Whenever natural vegetation is not desirable for revegetation, species having forage value for wildlife and livestock such as those recommended for Montana in the Interagency Forage, Conservation and Wildlife Handbook (1973) should be used.

Noxious and poisonous plant distributions also pose some problems in that these species readily invade disturbed areas such as those produced by construction activities. Areas of disturbance close to existing noxious and poisonous plants invite expanded distribution of these species. This situation causes a reduction in forage production and poses a hazard to livestock and wildlife.

The large amount of dust created during the summer construction period will cover nearby vegetation. This could cause a reduction in photosynthetic activity because carbon dioxide gas exchange may be reduced. The net result may be a decrease in total biomass and hence, forage production.

7.1.4.3 Corona Effects

Electrochemical Oxidants

Electric transmission lines are known to produce electrochemical oxidants. The most important ones are ozone (O_3), peroxyacetyl nitrate (PAN) and nitric oxides (NO_x). The amount of toxic gases produced is generally greater with higher voltage lines (500-765 KV).

The threshold level for vegetation injury varies by species and within species, but in general, for the most sensitive plants, it is from 0.05 to 0.12 parts per million (ppm) for 2-4 hours exposure to ozone (Hill, et al., 1970). The response or injury sustained by a given dosage also varies by stage of plant growth, nutrition, light intensity, relative humidity and temperature. Actual measurements made under dual 500 KV lines indicate that between 0.001 to 0.002 ppm of ozone are generated by the transmission lines (Kitchings, 1974). However, further tests are needed under varying conditions.

The plant species most sensitive to ozone are Bel W3 Tobacco (.035 ppm) and pinto bean (Heck, et al., 1965). Heck, Dunning and Hindawi (1965) found that the threshold of injury from ozone varied from day to day at the same location and the concentration levels that induced damage varied from one area to another. According to the above researchers the general vegetation injury threshold for vegetation is .03 ppm for 4 hours of sustained exposure.

The synergistic effect of O_3 combined with sulphur dioxide (SO_2) produces injury to plants at lower concentration levels than the levels of each acting alone. The above studies indicate the difficulty to predict that a given concentration of ozone will not cause damage to vegetation. Research is needed, especially in local areas, to determine what concentration levels will injure native and crop vegetation under various environmental conditions.

In eastern Montana, some of the tree species more sensitive to ozone are ponderosa pine, boxelder and green ash (U.S.F.S., 1973). Sensitive crops include alfalfa, barley, oats, beans, rye, sweet corn

and wheat. Other sensitive vegetation includes snowber and lilac (*Syringa vulgaris*) (Hill, 1970).

Another plant toxic produced by the electrochemical reaction of transmission lines is peroxyacetyl nitrate (PAN). Threshold concentrations resulting in injury to sensitive plants vary from .01-.05 ppm for an hour or more (Shurtleff, et al.,) to 0.01ppm for 6 hours of exposure (Hindawi, 1970). Presently there is no literature specifying how much PAN is produced by a 500 KV transmission line.

In the study area some of the plants more sensitive to PAN are alfalfa, sugar beet, lilac, oat, ponderosa pine and rose.

The two toxic chemicals mentioned above are produced from NO_x in the presence of light and hydrocarbons. Nitrogen dixiod, one of the nitric oxides, acting alone will visibly injure vegetation if concentration levels approach 2.5 ppm for four hours of sustained exposure (Taylor, 1967). In another experiment, Taylor and MacLean (1970) found that very sensitive species such as pinto bean and tomato may be injured at 6 ppm for only 2 hour exposure.

In the study area the only plant that has intermediate toxic sensitivity to NO_3 is rye.

The above discussion has centered on known threshold concentrations of the three most important toxic chemicals produced by transmission lines which cause visible vegetation injury. It is believed that photosynthetic activity and growth are adversely affected at levels lower than the threshold concentrations (Treshow, 1965). For example, Darley and Middleton (1966) state that less

than 1 ppm of NO_2 affects plant growth. Dugger, Mudd, and Koukol (1965) have reported that sensitive plants such as tomato have suffered growth suppression after several days exposure to low concentrations of PAN.

Work done by Taylor, Dugger, Thomas and Thompson (1961) with citrus trees and a study by Miller, Parmeter, Flick and Martinez (1969) with ponderosa pine seedlings also indicate that low concentrations of ozone suppress growth.

7.1.5 Wildlife and Fisheries

7.1.5.1 Wildlife

The effects of extra-high voltage transmission lines on wildlife are speculative. Therefore, an indirect approach must be taken to assess potential impacts. However, caution must be applied in siting a power line where conflicts with wildlife might exist.

Construction Period

It is noteworthy that mechanical injury to the environment will have repercussions on the fauna. Many of the vertebrates will be temporarily displaced during the construction period. They may return after the line is installed, but the rate of return and effect on subsequent densities are unknown.

Vegetation damage and/or removal during the construction phase may be particularly detrimental to certain game species such as sage grouse and antelope. The removal of large areas of big sagebrush which antelope use for food and sage grouse use

for food and cover would permanently reduce the carrying capacity of the affected areas for these species. Also the removal of tree cover and certain shrubs (i.e., skunkbush) would be detrimental to mule deer and turkey populations.

If construction operations occur during the nesting season, some nests will be destroyed and others abandoned. This factor is most important for birds (such as raptors) which are relatively rare or for which nesting habitat is limited. Raptorial birds are more prone to abandon nests prior to hatching time. To minimize this hazard, construction in forested areas should be forestalled from April 1 through June 15, and raptor nesting cliffs in all habitats should be avoided by a mile-wide buffer zone. The corridor should also avoid elk calving areas especially where the available habitat is limited as in the Bull Mountains.

Positive Effects

Deforestation of a swath through forested areas may have long-term effects on wildlife. Lay (1938) found that woodland clearings had 41 percent more bird species and 95 percent more individual birds than woodland interiors. Egler (1953, 1957) found that cleared areas produce more food for some game species. These studies suggest that the ecotone created by opening a swath in the forest may have a positive effect on some wildlife species if they are not otherwise deterred by the presence of a transmission line.

Washington and Oregon have a large proportion of existing 500 KV transmission lines, and both states have significant elk and deer populations. In the absence of quantitative data, game biologists in those states report no obvious negative effects of the lines on any wildlife species, but rather that some deer and elk are foraging in those power line corridors where plant foods have not been eliminated by herbicides (White, Ebert, Mericle, Parsons and Lockhart, 1974).

Tabor (1974) is engaged in a long-term study of the effects of transmission lines on wildlife in the Cedar River area in Washington. He reports heavy use of the transmission line swath by deer and elk but he does not give the size of the line in his study area. Brown (1974) reports that mule deer, bighorn sheep (Ovis canadensis), and elk are crossing, feeding, and bedding near an energized 500 KV line in Montana (Dworshak to Hot Springs).

In areas where suitable trees and cliffs are unavailable, raptorial birds and ravens (Corvus corax) will probably nest on the power line towers. Nelson (1974) reported nests on transmission line towers between Twin Falls and Hell's Canyon, Idaho. Some of these were active golden eagle (Aquila chrysaetos) eyries; the rest were used by the osprey (Pandion haliaetus), raven, red-tail hawk (Buteo jamaicensis), and ferruginous hawk (Buteo regalis). The power lines which Nelson surveyed range from 34.5 KV to 230 KV, but raptors also nest on 500 KV lines. Active raven and red-tail hawk nests were observed on 500 KV towers in Washington and Oregon (Unpub. data).

In addition to providing nest structures, transmission line towers provide suitable roosts and hunting perches for raptors.

General Avoidance Reactions

Although no scientific studies are available which demonstrate that large ungulates avoid transmission lines, Klein (1971) reports that in Scandanavia reindeer (*Rangifer tarandus*) are deterred from crossing power line rights-of-way, especially for the first year or two after construction. The "hum" of the power lines is believed to disturb reindeer and results in difficulties in herding.

There is some evidence that gulls are reluctant to fly under transmission lines (Gunther, 1956), and Willard and Willard demonstrated that waterfowl modify their flight paths to avoid transmission lines. As a preliminary test to discover if raptors, and especially the endangered peregrine falcon, were frightened by the presence of a line, a male gyrfalcon (*Falco rusticolus*) and a female peregrine falcon (both of which were trained for falconry by Peter Widener of Missoula, Montana) were released below the 500 KV Dworshak to Hot Springs line. Both birds initially flew near the conductors as if inspecting them, but both repeatedly flew beneath the lines and neither showed aversive behavior.

During a study in Wisconsin, it was observed that Canada geese in normal flight never flew under power lines (Hunt, 1972), and no geese were known to be shot by hunters within one-quarter mile of power lines. Also, ducks were less wary of power lines, but the wariness varied with species. The number of ducks shot

on a private marsh declined about two-thirds after a power line crossed the area, and shooting was limited to local birds early in the season (Hunt, 1972). Thus, improper placement of this line might have a negative effect on waterfowl hunting.

How wilderness species such as the grizzly bear (*Ursus horribilis*) will react to a 500 KV line is unknown. Until data are available showing the effects of transmission lines on each species, areas where sensitive and endangered animals occur should be avoided. In Japan, where this caution was not employed, most of the morality (ca. 14 birds per year) of the endangered Japanese sacred crane (*Grus japanensis*) is due to collisions with transmission lines. Only about 200 birds remain (Archibald, 1974).

Audible Noise

In the U.S. Environmental Protection Agency publication (EPA, 1971 a) entitled "Effects of Noise on Wildlife and Other Animals", no mention is made of transmission lines as a possible source of noise pollution; but even in fair weather, corona noise is audible though not uncomfortable near 500 KV lines. Terrestrial fauna may avoid the corridors, but it is improbable that animals on the ground will suffer cochlear damage.

Birds nesting on towers may suffer damage to their auditory apparatus. Guinea pigs (*Cavia cobaya*) suffered metabolic changes at all frequency levels when subjected to 100 db noise at various frequencies for 3 hours (EPA, 1971 a).

Electrochemical Oxidants

Of the chemicals produced by electric transmission lines, ozone, nitrogen dioxide, free radicals, singlet oxygen, and PAN are toxic to life forms (Young, 1973). Mammals subjected to 0.05-0.20 ppm ozone suffered irritated mucous membranes, decreased visual acuity, sphering of red blood cells, structural changes in myocardial nuclei, and increased mortality in the newborn (Jaffe, 1967). Test animals with repiratory infections suffered increased mortality from a 3-hour exposure period at only 0.08 ppm ozone (Jaffe, 1967) humans exposed for 10 minutes to nitrogen dioxide at 5 ppm suffered increased airway resistance. After 30 minutes at 90 ppm pulmonary edema developed in 18 hours. Long term exposure at 0.062-.109 ppm resulted in increased incidence of acute respiratory disease (EPA, 1971 b).

Although pertinent data on production of the other electrochemical oxidants are largely lacking, ozone is probably the only oxidant that may approach toxic levels near transmission lines. Frydman, et al. (1972) gathered ozone concentration data near 765 KV energized conductors and stated that "no measurable amounts of oxidants attributable to the presence and operation of the high-voltage installations were detected". Scherer, et al. (1972) and Fern and Brabets (1974) also concluded that ground concentrations of ozone due to EHV transmission lines are negligible.

In each of the references cited above, the researchers were concerned with danger to terrestrial life. The closest ozone readings were taken 6 meters downwind from the conductors. To determine if birds nesting or perching on the transmission towers will be poisoned, critical data are needed during all weather conditions and closer to conductors.

Collisions

Nocturnal migrants are especially prone to collisions with man made obstacles. Airport ceilometers, TV towers, buildings, transmission line towers, and even the Washington Monument have resulted in bird losses (Terres, 1956, and Willard and Willard, unpublished). Probably the greatest kill on record, an estimated 50,000 birds, occurred at a ceilometer (Johnston and Haines, 1957). Most of the birds that die are passerines--only occasionally do waterfowl add to the figures (Kemper, 1964). Taylor and Anderson (1973) reported only 4 grebes and 1 coot among 7,782 birds killed at a 1,484 foot TV tower. The height of the structure is one factor in determining the number of birds killed. Kemper (1974) reported that a 500 foot tower caused no deaths, while a nearby 1,000 foot tower killed 30,000 birds in a short period.

Although electric conductors and towers have not been responsible for losses as great as at TV towers, some bird deaths do occur. Banko (1960) reported trumpeter swans (*Olor buccinator*) collide with wires in foul weather. Borell (1939) recovered three sage grouse which apparently died on impact with telephone

wires. Cornwell and Hochbaum (1971) reported several instances of ducks killed on impact with barbed wire fences, power and communication lines. Twenty-one of 70 mute swans (Cygnus olor) killed (in a one-year interval in Great Britain) were wire strikes (Harrison, 1963). Other wire collision records include a male Allen's hummingbird (Selasphorus sasin) (Hendrickson, 1949); approximately 1,000 night migrants at Oak Ridge, Tennessee (Johnston and Haines, 1957); fulvous tree ducks (Dendrocygna bicolor) in Louisiana (McCartney, 1963); ring-necked ducks (Aythya collaris) (Mendall, 1958); 5 lesser sandhill cranes (Grus canadensis) (Walkinshaw, 1956); 2 ring necked pheasants (unpub. data); and the Japanese sacred cranes mentioned earlier (Archibald, 1974).

Stout (1967) accumulated records of nonhunting mortality of waterfowl. Of over 3,000 birds recovered dead from many causes, 1,507 were killed on wire strikes. He found that puddle ducks were most prone to wire strikes, males were more prone than females, and most strikes occurred during migration. This study and the others cited above suggest that waterfowl migration routes and key concentration areas should be avoided when siting transmission lines. The tendency of waterfowl to fly near the ground when approaching stopover areas and when crossing ridges and mountain passes (Eng, 1974) also suggests that transmission lines should avoid these topographic features where they coincide with migration routes.

Electrocution

The electrocution of large numbers of eagles on low voltage distribution lines has been documented for over 15 years. Dickinson (1957) reported that possibly 100 eagles were electrocuted annually near Aberdeen, Idaho. In 1972 the U.S. Bureau of Sport Fisheries and Wildlife accumulated data on 155 raptor electrocutions; of these, 135 were golden eagles (1973b). It was not until the 1970's that the Rural Electric Association and Bureau of Land Management began regulating power line configurations to reduce bird losses (REA., 1972, and Crawford and Dunkeson ,1973). Even at present, regulatory measures are either voluntarily employed or are enforceable only on public lands.

Researchers concur that transmission lines greater than 67 KV have not been responsible for electrocutions (Boeker, 1974 and Nelson, 1974). The 500 KV line considered in this report should not produce any bird electrocutions except those due to incidental lightning strikes and flashovers.

Other Effects

If the public has access to maintenance roads, hunting pressure on game species will increase in some areas, and raptors and other birds which perch and nest on the towers will receive increased pressure from indiscriminate shooting. Shooting of perched raptors from roadways near power lines can reach significant proportions. In a western Utah study area Ellis et al. (1969) recovered 30 dead raptors in one day along a 12-mile segment of distribution lines. None of these birds showed electrocution

burns. Most exhibited bullet and shot holes although some were dead over one year. Fourteen of the birds were golden eagles. Extensive surveys of other likely kill sites revealed additional shot birds, but nothing as extensive as along the initial survey road.

Where increased hunter pressure is undesirable, public access should be denied, and in areas where raptors are likely to perch and nest, it is to the birds' advantage if public roads are at least one-half mile distant.

The magnetic fields around the conductors may yield another hazard to bird life. Keeton (1969), expanding on the work of others, found that pigeons (Columba liva), released at an unfamiliar site, were able to efficiently navigate homeward when released under overcast skies. Under overcast conditions, one likely environmental cue used to navigate is the earth's magnetic field. If some wildlife species do use magnetic fields to orient and navigate, the effect on the young of these species that are reared near a magnetic field of high voltage transmission lines should be studied.

Negative Effects of Wildlife on Transmission Lines

In two years, Bonneville Power Administration suffered 32 outages as a result of unexplained flashovers (West, et al., 1971). Subsequent laboratory studies implicated raptorial birds as the most probable source of this problem. In theory, a bird perched on or flying near the tower defecates near the insulator string and the stream of excreta bridges the gap between a conductor and the tower. Ausland (op. cit.) stated that repeated

defecations on insulator string below a raptor nest are also responsible for flashovers.

One possible solution is to make the towers unsuitable for perches and to destroy nests, or make the towers unsuitable for perching and nesting only immediately above the insulator strings, and allow the birds to nest where they will cause no damage.

7.1.5.2 Fisheries

The potential effects of high voltage transmission lines on fish are unknown; however, several possible detriments could result from the construction and presence of high voltage lines. Stream siltation resulting from line construction might negatively influence spawning of some fish species, but the warm water fish found in this area will probably not be affected by siltation. If the power line induces an electric or magnetic field at its crossing point over the Yellowstone River, migrating fish species might be affected. Rommel and McCleave (1973) reported that Atlantic salmon are sensitive to such fields. If important Yellowstone River fish species (i.e., paddlefish) show this sensitivity, and it takes the form of an avoidance reaction, spawning or other migration patterns might be severely affected.

7.1.6 Meteorology

7.1.6.1 Construction

Climatology

No impact of construction or operation of the transmission line on macro or regional climate is anticipated. Construction

will impact microclimate insofar as the existing vegetative cover is disturbed in access road and right-of-way preparation. The clearing of vegetation will result in higher wind speeds near the ground and a corresponding decrease in ground level humidity in the cleared area. The local radiation budget will also be altered due to increased solar insolation reaching the ground. Restoration of the previously existing vegetation after the construction period should reverse these impacts.

Air Quality

Impacts on existing air quality will include an increase in dust levels, vehicular emissions, and possibly emissions from open burning. Dust caused by vehicular traffic and construction work will cause some increase in particulate pollution. Efforts should be made to minimize dust by sprinkling roads and construction areas with water and by retaining the vegetative ground cover whenever possible. Gaseous and particulate vehicular emissions will cause a temporary impact on air quality but no long term detrimental effects should result. Open burning of cleared vegetation or other wastes is also a potential source of particulate and gaseous emissions and should be avoided. Any open burning will be subject to existing state and federal regulations.

7.1.6.2 Operation

Climatology

No impact on climate due to transmission line operation is anticipated.

Air Quality

Because the production of oxidants such as ozone and nitrogen oxides occurs during corona discharge, the transmission line will have some impact on air quality. Only a sparse amount of information is currently available on which to base a prediction of the levels of oxidant production and hence the magnitude of impact of a 230 KV transmission line. Information which is available tends to indicate that the oxidant production rate will be so small as to make any impact negligible.

Oxidant measurements were made by Frydman, Levy, and Miller in the vicinity of energized 765 KV lines under various terrain and weather conditions (1972). Frydman, et al., concluded, "Under conditions of these tests, no measurable amounts of oxidants attributable to the presence and operation of the high-voltage installations were detected".

Roach, Chartier, and Dietrich (unpub.) made wind tunnel measurements of ozone and oxides of nitrogen production rates for single and bundle conductors of transmission lines in wet and dry corona. These production rates were combined with available corona loss data for the existing Apple Grove Project 765 KV test line. Diffusion calculations using a mathematical model (Gaussian line source model) were made to estimate the maximum ozone and oxide of nitrogen concentrations to be expected near the Apple Grove line. The hourly averaged concentrations predicted for ozone were less than .01 ppm. Nitrogen oxide concentrations were reported to be an order of magnitude less than the ozone values Roach, et al., concluded that the predicted concentrations were too

low to be deleterious to the environment as they were less than the values specified as harmful to plants and animals in the "Air Quality Criteria" for photochemical oxidants and for nitrogen oxides published by the U.S. Department of Health, Education and Welfare.

Scherer, Ware, and Shih (1972) reported on three different laboratory investigations of oxidant production rates. These experimental rates were also combined with Apple Grove 765 KV test line corona loss data to give oxidant production rates appropriate for a diffusion model analysis. Using different diffusion coefficients in a model similar to that used by Roach, et al., results similar to those of Roach, et al., were obtained. The maximum 10 minute average concentrations predicted, assuming no oxidant decay, was .02 ppm. On the basis of the predicted concentrations, Sherer, et al. concluded, "Analytical studies based upon conservative assumptions and calculations indicate that the probability of measuring ground level incremental concentrations is essentially zero".

In a study for the Environmental Protection Agency, Whitmore and Durfee (1973) made laboratory measurements of ozone production rates from a sub-scale simulation of a high-voltage transmission line. The rates measured were consistent with those determined by Roach, et al. and Scherer, et al. Based upon their own measurements of average ozone production rates, and estimated average corona loss, and three different ozone half lives, Whitmore and Durfee used a simple "box" dispersion model to calculate the ambient ozone concentration for three areas containing high concentrations of transmission lines. The total number of miles

of three-phase transmission lines operating at 115 KV and higher was used as the emission source in each area. Ozone was allowed to mix uniformly throughout the dimensions of the "box" (actually a cylinder) which were defined by the horizontal area containing the transmission lines and a vertical height of 1 km. The "box" was assumed to be closed so that no mixing with air outside the box was allowed. The resulting steady state concentrations were:

O_3 Half-Life (hr.)	Concentration (ppb by volume)
1	1.2×10^{-3}
10	1.2×10^{-2}
100	1.2×10^{-1}

Such average concentrations would not appear to significantly effect air quality.

In summary, the available laboratory and field data for high voltage transmission lines operating at voltages up to 765 KV appear to indicate that no significant impacts on air quality will occur due to oxidant production in corona discharge with respect to existing air standards.

7.2 Cultural Environment

7.2.1 Existing Land Use

The severity of the transmission line impact on existing land use depends critically on both the general corridor location and the placement of individual towers. This is due to variation in degree of incompatibility of the line with the variety of present land use in the area.

7.2.1.1 Agricultural Land

The impact of the transmission line will depend on the type of agriculture being practiced in any given area. In addition to these differences, impacts during construction are expected to be quite different from operational impacts.

In areas of grazing land, the amount of land taken out of production is probably minimal once the building of the line is completed. Assuming good reclamation after construction, the grazing land cost should be only the actual tower sites and maintenence roads that are kept operational. The construction phase is expected to have greater impact. During construction of the line it is believed that cattle will avoid the construction site. A rancher in the study area noticed that his cattle stayed away from the right-of-way during the construction of the existing 230 KV line from Colstrip to Billings (Hope, 1974). The avoidance reaction was probably due to the large amount of noise coming from construction equipment. As a result of avoiding the right-of-way and subsequent loss in total grazable area during the summer, the cattle had to be moved to the bottom meadows (alfalfa producing areas) earlier than normal. This meant a loss in the alfalfa seed crop. After the towers are in place and probably before the conductors are strung, the avoidance reaction is not as strong, and the cattle may actually use the towers to rub against.

In areas of dry land cropping, the transmission line will be more disruptive. Land physically occupied by the tower and any permanent maintenence roads will be lost from production. In addition, the towers and supporting guy wires will represent physical obstacles to machine operation, and thus will upset

present efficient geometric patterns of cultivation. The presence of the line will greatly restrict the possibilities of thorough aerial spraying programs and may contribute substantially to weed control problems. The impacts during construction should be somewhat more severe because men and the equipment will use an area wider than the completed towers will occupy. As a result, this wider area will be lost for one growing season.

The largest potential impact is on irrigated cropland, particularly that land which utilizes roll-type, sprinkler irrigation. However, due to generally smaller field size, the possibilities of minimizing impact through careful tower site selection may be greater for irrigated land than for dry cropland. The following points of impact for irrigated land should be noted: (1) Service roads or trails passing through gravity irrigation systems would require adequate crossing over major and lateral canals. (2) Where sprinkler systems are in use, travel along access roads would be restricted during periods of irrigation. Also any placement of towers in the path of the sprinkler would act as a barrier to the sprinkler system and greatly hamper opeations. (3) If water from the sprinkler touches the transmission wires, it would act as a conducting media for electricity to flow back to the sprinkler and severely shock anyone touching it. (4) Travel along service trails when soils are wet would cause rutting and erosion from irrigation water and run-off.

7.2.1.2 Residential Areas

The impacts of the transmission line on a residential area would be severe, ranging from physical and electromagnetic impacts to more abstract aesthetic impacts.

The aesthetic impact is mostly due to the visual aspects of the line. The physical dimensions of the proposed transmission line would dominate the landscape of most residential areas, and residents would probably consider the line to be a negative visual addition to their community. A transmission line in a residential area will also act as a physical and psychological barrier to expansion. Unless built along an existing corridor, the line imposes a new linear pattern on an area and so constrains future building options.

In addition to the physical and visual impacts of a transmission line, there are electrical effects that would be a nuisance in a residential area. The most obvious of these are the effects that the energized transmission line has on radio and television reception. Interference depends on the distance the receiver is from the line, the strength of the signal received in that area, and weather conditions. Section 5.4 contains additional information on these effects.

All of the above impacts on residential areas are those imposed by the existence and operation of the line. The construction of the line will create impacts in a residential area in terms of a general increase in dust, noise and traffic congestion, even if this activity is of relatively short duration.

7.2.1.3 Commercial and Industrial Areas

Many of the impacts that have been mentioned in connection with residential areas will likewise exist for commercial and industrial areas. However, the emphasis may be quite different. Although

the visual imapct can be expected to be negative, a transmission line would probably not dominate an industrial landscape as much as a residential area. In addition, aesthetic considerations are not generally held to be as important in an industrial or commercial area. The linear constraint on the use of space that the transmission line represents and the resulting barrier to development, might be more severe in its impacts on commercial and industrial space than on residential areas.

During the construction of the line, commercial and industrial developments would experience an increase in dust, noise and traffic. These impacts should not be as heavy as in a residential area.

7.2.1.4 Highways and Recreational Areas

Once the transmission line is completed, the impact on highways and recreation areas will be mostly visual. The severity of this impact will depend on the proximity of the line to such areas and the background against which the line is viewed.

In addition to the visual impact of the line, highways and recreation areas in the immediate vicinity of the line may experience radio interference.

During the construction period there may be many local inconveniences. Traffic may be slowed up or detoured and the construction activity will create noise and dust which cause considerable nuisance to nearby recreation areas.

7.2.1.5 Archaeologic Sites

The impact on archaeological sites will depend on both corridor selection, and individual site selection. Since much of the study area has not been thoroughly inventoried, impacts could be lessened by putting an archaeologist in the field once the corridor selection has been finalized but before construction has begun.

7.2.1.6 Existing Corridors vs. Creation of New Corridors

There is currently much debate over the advantages and disadvantages of siting new transmission lines in existing corridors. In this section a brief summary of the major arguments will be listed.

Most of the arguments against utilizing existing corridors are concerned with efficiency or reliability. However, there may also be a question of equity. The main arguments are:

1) Cost considerations

   Use of existing corridors may involve taking a more circuitous route than a new corridor would require. Thus, there would be more tower structures, more miles of conductors more land crossed and more losses of energy.

2) Reliability considerations

   Siting all transmission lines in a single corridor increases the probability of a total loss in power. A single localized event could take out all the lines in that corridor.

3) Equity considerations

Erecting additional transmission lines in an existing corridor may mean that those people already bearing the visual and land use costs of existing transmission lines will have to bear the additional costs of the new lines.

On the other hand, there are arguments in favor of common corridor siting. These are all concerned with some aspect of efficiency.

1) Minimization of impact

The main argument for common corridor siting is that the impact of an additional transmission line in an existing corridor is much less than the impact of creating a totally new corridor. This is true with respect to visual and aesthetic impacts and also with respect to linear pattern constraints on land use and development. Essentially, the argument is that land devoted to transmission lines is already limited in its use, and thus it will not experience any extensive new limitation to its future use.

2) A second, closely related argument in favor of common corridor use is sometimes called the "separate facilities" argument. It is put forward as a justification for zoning ordinances and even the existence of smoking - no smoking cars on

railroads. The idea is to provide distinct alternatives, rather than subjecting the total population to the average conditions. This allows those who are offended the option of moving away from abrasive conditions.

Although there are arguments on both sides, the goals of minimizing impact and making efficient use of land dictate common corridor use whenever practical. This may mean slightly higher rates for electric customers and additional costs for those already bearing a heavy portion of the external costs of transmission lines. However, the alternative (continued construction of new corridors) would be a totally dissected landscape.

7.2.2 Population

The proposed transmission line should have no long term effect on the amount of population in the study area or the distribution of that population. There will be a short term influx of workers and their families during construction, but this should be only a transient phenomena. Maintenance of the line, once it is in service, will have no appreciable effect on study area population size.

7.2.3 Social Aspects

The impact of tne transmission line on social aspects will be mostly due to the construction activity. The temporary influx of construction workers into a sparcely populated area may strain

established life styles. To the extent that construction workers move into the area with families, some temporary problems may arise in school space and other local public services. Much of this will depend on where the workers reside while building the line. An area like Billings could absorb the influx much easier than the rural areas.

The post construction social impacts should be minimal or non-existent.

7.2.4 Economic Aspects

The economic impact of the transmission line can be examined from many different points of view. It is worthwhile to consider each of them.

From the company's point of view, the line allows the sale of power output from Colstrip Units 1 and 2. Without the transmission line, the investment in the units is worthless.

From the viewpoint of the electric customer, a new source of electrical energy is made available. With costs already sunk into these generating units, the next best alternative generation source would be much more expensive.

Viewing the study area as a whole, much of the short-run concern is with the immediate effect on employment and income. Based on assumptions used in the applicants' environmental

analysis[1] income effects would be as follows:

Direct Construction Income	
Local labor income	$ 744,600
Outside labor income	2,978,400
Total direct labor income	3,723,000
Indirect Income Generation	$1,111,128

From these figures, total income flowing to local residents will be $1,855,728.

There should be additional local income generated from direct purchase of local materials and services. Total amounts are difficult to estimate but certainly such things as cement will probably be purchased locally even if the structural steel and conductors are from outside the study area.

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[1]Cost Assumptions:	
Total cost 110 miles of single transmission line	$12,410,000
Ratio of labor costs to total costs	30%
Labor Force Characteristics:	
Local labor	20%
Outside labor	80%
Outside labor with families	50%
Outside labor without families	50%
Expenditures Made Locally by Laborers:	
Local labor	70%
Outside labor with family	70%
Outside labor without family	35%
Locally derived goods	40%

(Westinghouse, 1973)

Job creation is hard to estimate. Aside from the direct employment, it is hard to imagine much additional employment stemming from a construction project of such short duration. Temporary expansion of local services would probably result in longer hours of work for those already employed rather than increased numbers employed.

Tax revenues flowing to the state, the counties and the towns involved are estimated using a 6% rate for state income tax, and a 1.6% property tax rate (Westinghouse, 1973). The state income tax flowing from the construction wages is estimated to be $223,380. The property taxes flowing from the completed line are estimated to be $198,560 annually.

8. Optimum Corridor Selection

Selection of an optimum transmission line corridor is made through interaction of the engineering analysis of the proposed line (Chapter 5) with the inventory of natural and cultural environmental elements found in the study area (Chapter 6). Therefore, a matrix has been constructed with a list of the environmental elements on the horizontal (x) axis and engineering specifications and criteria on the vertical (y) axis.

The matrix can be used to evaluate the impact of the transmission line on the environment and environmental constraints on corridor selection. To identify and assign the degree of impact, a 5-rank number system has been selected. According to this system, 1 is equivalent to very severe impact, 2 equals severe impact, 3 equals moderate impact, 4 equals slight impact, and 5 indicates that no impact relationship has been established.

In selecting and evaluating alternative two-mile wide transmission line corridors it is first necessary to know the natural and cultural features relevant to corridor selection. By necessity, the detail of data level for initial corridor selection is broad when compared to the more specific information needed for centerline determination. Each resource identified in Chapter 6 has been used to evaluate the suitability of transmission corridor selections. Therefore, each sub-element of each resource map has been assigned suitability values based on the 5-rank system for corridor selection purposes. The matrix portraying these value assignments is shown on the following page.

After a mylar or transparency of each resource map has been assigned ranking values, the mylars are overlayed on top of one another. Possible corridors for the transmission line are established by attempting to avoid all areas of severe impact. Where two areas of severe impact lie in close proximity, a trade-off must be made between the two elements or areas involved in deciding which area or element could be crossed with the least impact. Comparison of corridors has been made by evaluating and tabulating the amount of severe impact area which each route crosses. The optimum corridor is the one which has the minimum degree of total impact on all the elements shown in the matrix.

RANKING SYSTEM
1. VERY SEVERE
2. SEVERE
3. MODERATE
4. SLIGHT
5. NO RELATION ESTABLISHED

NATURAL ELEMENTS

TRANSMISSION LINE CHARACTERISTICS / ENVIRONMENTAL CHARACTERISTICS	PHYSIOGRAPHY										HYDROLOGY							SOILS		
											SURFACE WATER							EROSION HAZARD		
											WETLAND			STREAMS						
	MDL- MDL-T	DL- DL-T	PL- PL-T	DT	BL	CL	HS	LS	UL	V	Marshes	Ephemeral Lakes	Perennial Lakes	Major	Minor	Intermittent	Ground Water	Severe	Moderate	Slight
PHYSICAL: RIGHT OF WAY SELF-SUPPORTED TOWER BODY SELF-SUPPORTED TOWER FOUNDATION GUYED TOWER BODY GUYED TOWER FOUNDATION CONDUCTOR	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4
ELECTRICAL: ELECTROSTATIC ELECTROCHEMICAL ELECTROMAGNETIC RADIO INTERFERENCE TV INTERFERENCE AUDIBLE NOISE HEAT	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CONSTRUCTION: CLEARING RIGHT OF WAY ACCESS ROADS STAGING SITES FOUNDATION DIGGING TOWER SITES TOWER ERECTION CONDUCTOR STRINGING	2	2	3	3	2	3	3	3	3	3	2	2	3	3	2	3	5	1	2	4
CONSTRUCTION CREW (SIZE VARIATION)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
RECLAMATION	2	2	3	3	2	3	3	4	4	4	3	3	5	5	5	5	5	1	2	4
MAINTENANCE	3	3	4	4	4	4	4	4	4	4	2	2	3	4	4	4	5	1	2	4

TRANSMISSION LINE CHARACTERISTICS	VEGETATION TYPES													
	TIMBER				RIPARIAN		GRASSLANDS							
	Subalpine	Douglas Fir	Eastern Ponderosa Pine	Ponderosa Pine Savannah	Cottonwood-Willow	Boxelder-Rose-Chokecherry	Big Sage-Wheatgrass	Big Sage-Wheatgrass-Grama	Big Sage-Wheatgrass-Needle & Thread-Grama	Wheatgrass-Fescue	Wheatgrass-Needle & Thread-Green Needlegrass	Needle & Thread-Wheatgrass-Grama	Wheatgrass-Needle & Thread-Grama	Near Pristine Vegetation
PHYSICAL	1	1	1	3	1	1	4	4	4	3	3	3	3	1
ELECTRICAL	2	2	1	1	1	1	3	3	3	3	3	3	3	1
CONSTRUCTION	1	1	1	3	1	1	4	4	4	3	3	3	3	1
CONSTRUCTION CREW (SIZE VARIATION)	5	5	5	5	5	5	5	5	5	5	5	5	5	5
RECLAMATION	3	3	1	1	2	2	3	3	3	2	2	2	2	1
MAINTENANCE	1	1	1	1	1	1	4	4	4	3	3	3	3	1

TRANSMISSION LINE CHARACTERISTICS	WILDLIFE														
	TYPES											DENSITY			
	Elk	Antelope	Mule Deer	Whitetail Deer	Prairie Dog	Pheasant	Turkey	Waterfowl	Sage Grouse	Sharptail Grouse	Heron	None To Low	Low To Moderate	Moderate To High	Critical Areas
PHYSICAL	4	4	4	4	5	1	1	1	1	1	1	5	4	1	1
ELECTRICAL	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CONSTRUCTION	1	1	1	1	1	1	1	1	1	1	1	3	2	1	1
CONSTRUCTION CREW (SIZE VARIATION)	1	1	1	1	1	1	1	1	1	1	1	3	2	1	1
RECLAMATION	3	3	3	3	4	3	3	3	3	3	3	4	4	3	3
MAINTENANCE	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4

CULTURAL ELEMENTS

TRANSMISSION LINE CHARACTERISTICS	EXISTING LAND USE									POPULATION DENSITY				
	Irrigated Lands	Dry Crop Lands	Grazing Land	Transportation Corridors	Utility Corridors	Residential, Built-up	Residential, Scattered	Historic-Archaeologic Sites	Recreation Sites	Less Than 1	1-5	5-10	10-50	More Than 50
PHYSICAL	1	1	4	3	4	1	2	1	3	3	3	2	2	1
ELECTRICAL	5	5	5	5	5	3	3	5	3	3	3	2	1	1
CONSTRUCTION	1	1	3	1	3	1	3	1	2	4	3	3	2	1
CONSTRUCTION CREW (SIZE VARIATION)	5	5	5	5	5	5	5	5	4	3	3	4	4	5
RECLAMATION	5	5	5	5	5	5	5	5	5	5	5	5	5	5
MAINTENANCE	1	1	4	4	4	4	4	4	4	4	4	4	4	4

INTERACTION MATRIX FOR TRANSMISSION CORRIDOR SELECTION
Energy Planning Division
Department of Natural Resources & Conservation

9. Comparative Corridor Analysis

This chapter is the comparison of corridor A (the applicants' preferred corridor) with corridor F, chosen by the Energy Planning Division. These corridors are shown on the map overlay contained in the back cover of the report.

The alternative corridors proposed by the applicants have been tentatively eliminated as unsuitable for various reasons. Corridor B crosses areas designated for future mining immediately east of Colstrip. Moving westward this corridor crosses very rough terrain in the Little Wolf Mountains, poses direct interference with a proposed irrigation project north and east of Hardin and crosses more dry and irrigable cropland between Hardin and the Billings area than would alternative F. Corridor C was not a viable alternative because of its length and the fact that it would result in a completely new corridor. Also, this corridor crosses more areas of severe erosion hazard as well as some critical antelope and white-tail deer habitat. Corridor D fuses into corridor A in the west, but where it exists alone it does not follow an existing corridor and it crosses more land area than either route A or F. Also, corridor D's river crossings are not as desirable as routes A and F. The elements in the general environmental impact section are arranged similarly to Chapters 6 and 7.

9.1 General Environmental Impacts

9.1.1 Geology

The geological comparison of the corridors is handled on a section by section basis, beginning from Colstrip and progressing west along the two routes.

Colstrip to West Fork of Armell's Creek

This segment of the route includes both corridors. It spans the two forks of Armell's Creek and crosses two major tributaries of the East Fork. Between the East Fork of Armell's Creek and Stocker Creek is a divide area composed of clinker which also includes a topographically low area about two miles west of corridor F's end point.

Some rough terrain lies northwest of Stocker Creek. It is there that extensive excavation in this segment will be required.

West Fork of Armell's Creek to Sarpy Creek

This segment contains some relatively continuous natural corridors which provide distinct advantages over bordering areas. From the West of Armell's Creek, either the North Fork of Donley Creek or the flat-topped ridge immediately south of it lead directly toward the Sarpy-Colstrip Pass. Westward, the broad valley of Horse Creek continues straight west to Sarpy Creek. There are special areas within corridor F along this segment where excavation should be avoided, including clinker areas east of Sarpy-Colstrip Pass and along the north side of Horse Creek, and also areas of shale badlands near the mouth of Horse Creek.

The areas along the creeks form natural corridors, and within them the terrain is much less rugged than along corridor A several miles to the north. Some existing secondary and unimproved roads exist along corridor F which also has more potential for avoiding badlands and clinker areas; whereas, route A would require construction of continuous access roads and many spur roads to tower sites. Over most of corridor F, new access road construction will be limited to short, isolated stretches, mostly near small gullies.

Both corridors cross narrow belts of strippable coal in the Sarpy-Colstrip Pass area of this segment.

Sarpy Creek to Tullock Creek

Most of the area between Sarpy and Tullock Creeks is underlain by the Lebo shale member of the Fort Union formation. In the vicinity of corridor F, slopes are significantly more gentle than further north. Route A passes directly through an area of badlands, none of which need be encountered with corridor F. Careful planning would result in almost no road construction on this shale.

The Tullock Creek side of this divide is only one to two miles wide, and underlain by sandstone. Route A may possess an advantage over route F at Tullock Creek, in dropping more abruptly from the divide, but careful siting of the lines could render the advantage slight. A small amount of road construction will be required.

Tullock Creek to Bighorn River

With the exception of small occurrences of Lebo shale in the higher, gently rolling area of the drainage divide between these two streams, bedrock consists of sandstones of the Hell Creek and lower Fort Union formations.

Route A and the centerline of corridor F cross this area along nearly parallel paths, separated by a distance of about three miles. Route F follows a natural corridor which begins as a nearly flat-topped ridge that rises abruptly at Tullock Creek and continues westward, merging with the north-south divide ridge. Across the divide ridge, this natural corridor drops into the wide, gently sloping valley bottom of Pocket Creek and follows it the remaining distance to the Bighorn River. An additional advantage of this corridor is that there is an existing roadway or trail over most of its length. There should be little cut and fill road access along the ridge portion of this segment, and only local excavation along the Pocket Creek portion.

Route A from Tullock Creek to the Bighorn River cuts across irregular terrain that includes West Bossart Coulee, the main fork and several tributaries of West Burnt Creek, and Mission Coulee. Although some of this route can be reached or approached by existing unimproved roads and off-road travel, extensive new construction would be necessary for access to individual tower sites.

Pine Ridge Area

West of the Bighorn River crossing, corridor F progresses

southwestward, to pass south of Pine Ridge. It is recommended that the transmission line lie to the west side of the corridor for approximately the first four miles of this route. This would place the line west of the Bighorn River flood plain in a somewhat rough, forested area of dissected terraces and wide stream valleys where extensive construction will be necessary for access to some individual tower sites. This area is geologically and physiographically similar to the area of northern Pine Ridge that is crossed by route A. The primary difference, geologically, is that route F crosses only about 4 miles of this terrain, whereas route A crosses 8 miles. Also, route F lies within easy access of a major highway.

From this area to Interstate Highway 94, southwest of Pine Ridge, corridor F crosses a low relief area of gullies that drain away from Pine Ridge. The gullies are frequently steep-sided, and where they must be crossed, short road segments will be required. Some unimproved roads exist in this area and spur roads to tower sites that parallel the gullies will help minimize new construction.

Pine Ridge Westward

Near Pine Ridge, the two routes diverge widely. The entire sections of each route from Pine Ridge westward will therefore be discussed separately.

Route A

Yellowstone River to Broadview

North of the Yellowstone River, route A passes for about

35 miles through wide, low relief areas formed by the valleys of Railroad, Pompey's Pillar, Razor, and Crooked Creeks. This entire segment is underlain by Hell Creek sandstone. Part of this distance contains flat plateau or terrace surfaces. Steep slopes tend to be short and widely separated by areas of moderate to gently sloping land.

About 8 miles west of U.S. Highway 87 route A encounters an area of breaks. Of the possible routes through this rough area, route A takes good advantage of an available trail that follows a ridge to the rim above. A relatively minor amount of excavation will be required here, considering the roughness of the general topography. This emphasizes the significance of fortuitious tower siting in reducing geologic impacts in otherwise difficult terrain.

The remaining ten miles to Broadview crosses flat or nearly flat lands within or bordering the Comanche Basin. No road construction or extensive site excavation will be required in this area. The central part of the basin which the line would cross contains gumbo-forming clay which will not support traffic when wet.

Route F

Indian Arrow Area

For about 17 miles between Fly Creek and Pryor Creek, corridor F parallels existing MPC lines. The existing lines lie within natural corridors along Alkali and Indian Creeks' heads.

Although the corridor mainly traverses Clagett shale in this area, this formation apparently does not have the severe erosional problems that are occasionally associated with other shales.

Existing access roads parallel Alkali and Indian Creeks, and much of the terrain has gentle slopes. It is recommended that no new roads be constructed up the steep slope from the head of Alkali Creek to the plateau.

Pryor Creek to Yellowstone River

South of Interstate 90, it may be possible to span Pryor Creek without erecting towers on the flood plain. This would place the transmission line in moderate and occasionally gentle sloping terrain of Claggett shale.

Short segments of new road connecting existing roads and level areas for 1½ to 2 miles to the northwest would bring the line to an area of nearly flat terrace surface remnants. These continue most of the distance to the Yellowstone River.

Interstate 90 inhibits ready access to parts of the area between this highway and the Yellowstone. Locally extensive road construction may be required here.

Yellowstone River Terrace and Flood Plain

The widespread flatness of these areas renders bedrock geology an insignificant factor in transmission line construction, and also eliminate the need for construction of new access trails.

Seven Mile Creek Area to Acton

Numerous faults of the Lake Basin fault zone cause diverse lithologies along this segment of corridor. The differential resistance to weathering and erosion presented by these lithologies in turn create physiographic variety within the corridor.

Minimization of road construction requires particularly careful siting in this area, but some logical possibilities for consideration are apparent on 1:24,000 U.S.G.S. topographic maps. Some short new road segments will definitely be required.

The Acton area lies within the Comanche Basin, and is similar to terrain crossed by the MPC route farther north. Less than one mile of this terrain is crossed near the terminus of the EPD corridor.

Seven Mile Creek Area to Acton

Numerous faults of the Lake Basin fault zone cause diverse lithologies along this segment of corridor. The differential resistance to weathering and erosion presented by these lithologies in turn creates physiographic variety within the corridor.

Minimization of road construction requires particularly careful center-line siting in this area, but some logical possibilities for consideration are apparent on 1:24,000 U.S.G.S. topographic maps. Some short new road segments will definitely be required.

The Acton area lies within the Comanche Basin, and is similar to terrain crossed by route A farther north. Less than one mile of this terrain is crossed near the terminus of corridor F.

9.1.2 Hydrology

With the exception of the marsh area near Broadview, hydrologic impacts of corridors A and F are comparable. Both routes cross many small intermittent streams and both cross the Yellowstone and Bighorn Rivers.

The marsh area near Broadview is an ephemeral lake containing water only during parts of wet years, generally in the spring. By late spring or early summer it is usually dry enough to allow hay to be made from the grasses growing there. The impacts of crossing this area with a transmission line would result from having to enter the area with vehicles at times when the ground is wet. The thick clay which underlies the marsh would become seriously rutted at these times and would likely interfere with the agricultural uses of the site. The clay has the added disadvantage of providing a poor tower foundation. Route A crosses this area, whereas corridor F would not.

Hydrologic impacts upon small streams can be minimized or entirely avoided by careful route selection within the two-mile wide corridor. Water quality impacts can be minimized by keeping road construction as limited as possible and by using care in the construction process. However, the difference in water quality impacts between the two routes cannot be quantified.

The proposed transmission line would have little hydrologic impact upon the Bighorn and Yellowstone Rivers. Since the flood plains of these rivers are wider than the spacing between towers,

structures will be built on the flood plains. The size and spacing of the towers on the flood plains would prevent them from damming flood flows and thus increasing the extent of flooding. Even with much debris accumulated on the tower base, the restriction of water flow would be insignificant. However, large floods could damage or destroy the towers, thus jeopardizing the functioning of the line.

The geology and physiography of the Bighorn River crossing of route F at the mouth of Pocket Creek is very similar to that of route A's crossing. The route F crossing may require that only one tower be erected on the 100 year flood plain (U.S.G.S. Maps of Flood Prone Areas, 1:24,000, 1972 and 1973), whereas route A would probably require at least two.

The 100 year flood plain of the Yellowstone River is as wide as 0.8 of a mile within corridor F (U.S.G.S. Map of Flood Prone Areas, Billings East Quadrangle, 1969). Route A has two crossings as alternatives at the Yellowstone, with flood plain widths of 0.5 and 0.85 miles, respectively. Crossings at points of minimum width, however, are not necessarily the best. For a given flood, narrow portions of the flood plain would have either higher water stage or greater velocity flow (usually both) as compared to wide portions of the flood plain. Also, since flood plains are not without topographic relief, proper selection of tower sites within the flood plain can minimize flood hazards.

of tower sites within the flood plain can minimize flood hazards.

Certain construction practices on the flood plains can cause siltation of the rivers. These practices (which include operating vehicles in the stream and altering the stream banks) should be avoided but are not the result of the location of the corridor. Road construction on flood plains can be accomplished without significant hydrologic impact if done properly.

9.1.3 Soil

From Colstrip to the Bighorn River, the soil erodibility categories indicated on the "Soil Erosion Hazard" map reveal no significant differences in erodibility along the two major corridors being considered. However, corridor F contains more subdued local relief and gentler slopes within a network of natural corridors. This results in notable local decreases in sediment yield risk.

West of the Bighorn River, corridor F passes through larger areas of "slight" and "moderate" erosion hazard, and less "severe" hazard than does route A. This apparently major difference is modified by somewhat subdued physiography that is spanned by corridor F north of the Yellowstone River, and by corridor A south and southeast of Pine Ridge. Overall differences between the two corridors are not as distinct west of the Bighorn River as they are in the eastern half of the study area in terms of soil erosion.

9.1.4 Vegetation

The 13 vegetation types in Table 1 are separated into the degree of environmental hazard for the proposed 230 KV transmission line. This table is based on the criterion that riparian vegetation (which includes some irrigated cropland) poses a very severe risk for a corridor because of the associated water and wildlife factors mentioned in section 7.1.4. The eastern ponderosa pine type is in a severe category for a transmission line corridor due to the loss in forest cover (wood fiber and wildlife habitat) and the more extensive clearing and grubbing that is required. The vegetation types in the moderate category are those resulting in decreased forage production for livestock and wildlife. Vegetation types in a slight hazard category have a large percentage of sagebrush in them so that the total forage production lost is less than in grassland areas.

With careful placement of transmission towers in the two-mile corridor, the very severe, severe, and moderate hazard areas can be avoided.

Comparing the areas crossed corridor A and corridor F, there is little difference in the moderate and slight categories. However, the potential forest production loss (severe class) and amount of clearing required is greater with corridor A than corridor F. There is slightly more very severe land crossed by corridor F, but the difference is small enough that the greater amount of severe area crossed by corridor A overrides this factor.

Table 1

Vegetation Analysis of Transmission Line Corridors

Hazard Rating	Vetetation Types	Miles Crossed		% of Total Length	
		Corridor A	Corridor F	Corridor A	Corridor F
Very Severe	Cottonwood-willow	2	5	2	5
Severe	Eastern Ponderosa pine	28	17	26	15
Moderate	Ponderosa pine savannah Wheatgrass-fescue Wheatgrass-needle and thread-green needle Needle and thread-wheatgrass-grama Wheatgrass-needle and thread-grama	62	65	57	60
Slight	Big sagebrush-wheatgrass Big sagebrush-wheatgrass grama Big sagebrush-wheatgrass-needle and thread-gama	17	22	15	20
	Totals	109	109	100	100

Another important consideration is that the revegetation potential is greater in less sloping topography, especially in the stream bottoms when compared to steep, hilly, broken up topography. In this respect, the total amount of steep topography crossed by corridor F is much less than that crossed by corridor A, especially between Colstrip and the Bighorn River.

9.1.5 Wildlife

Since much of the known impact on wildlife will result from line construction, the least amount of new road construction is desirable. Adherence to established transmission corridors and highway rights-of-way also lessens interference of new lines with established migration and daily movement patterns of wildlife. Corridor F follows the existing 230 KV line and U.S. Interstate Highway 90 from Fly Creek to Billings and the Horse Creek road to Sarpy Creek. Corridor A follows no road or existing transmission line corridor for any significant distance.

Corridor A avoids elk and turkey habitat and does not traverse any critical antelope or mule deer wintering areas. Corridor A passes through the Pine Ridge area south of Custer which contains elk, turkeys, mule deer and sharp-tailed grouse. Corridor A also passes through some very critical antelope winter range north of the Yellowstone River near Railroad and Razor Creeks and cuts through the forested benchland north of Billings, a critical mule deer area.

Corridor F river crossings are perpendicular to the drainages and are located at points of seemingly minimal impact to wildlife and/or fisheries. The Yellowstone River crossing of corridor F is near Billings in marginal wildlife habitat. Corridor A's crossing, on the other hand, passes through excellent white-tailed deer, pheasant and waterfowl habitat as well as the important antelope, elk, mule deer and turkey areas mentioned above. At no place does corridor F closely parallel any major river which could result in a negative effect on waterfowl.

A mileage comparison of the two routes can be made by multiplying the traversed miles of medium to high quality and critical elk, mule deer, white-tailed deer, antelope, pheasant and turkey habitat by their assigned quality level on the "Wildlife - Mammals" Map and adding these values together for each route. By this calculation corridor F and corridor A have 480 and 657 miles of wildlife impact, respectively.

In the final analysis, every possible corridor would create some impact on wildlife, at least during the construction phase. Since so little is known about the effects of an operational 500 KV transmission line, wildlife may be compromised into an untenable position.

9.1.6 Cultural Environmental Impacts

The impact of the transmission line will depend on the degree of compatibility of the line with the prevailing land uses currently practiced in the transmission corridor. Even the aesthetic impact

of the line depends on characteristics of the landscape before the building of the line, and not just the physical dimensions of the line itself.

In going from Colstrip to a general area north of Billings, certain sensitive features must be crossed, the major feature being the Yellowstone River. The Yellowstone is sensitive because it is the seat of most of the population in the area and provides a rough center-line for most of the irrigated land in the area. Although both corridors will go through irrigated land at their respective Yellowstone crossings, route F will cross a wider band of irrigated land. However, irrigation in the immediate area is mainly by ditch and flooding methods, and therefore would not be substantially affected by the transmission line. The relatively small size of individual fields in this area might allow spanning entire fields. Thus, careful tower site selection is needed.

The second major irrigation system, the Bighorn River, is also crossed by both corridors. With careful tower site selections the impact on present irrigation systems should be negligible.

The impacts on dry crop land may be more severe than on the relatively small irrigated plots. This is because the size of the dry land plots may necessitate placing some towers in crop areas. Also, even careful tower siting may result in some interference with the large farming equipment used in the crop areas. Both two-mile wide corridors provide enough room to circumvent most present dry crop land; however, corridor A crosses one

extensive area of dry crop east of Broadview. Careful tower site selection will help, but all impacts cannot be avoided.

Although the archeological site inventory for the study area is general, corridor F is more compatible with known sites. Both corridors will cross major historical trails in the area, but the impacts should be slight, except for visual intrusions.

Probably the major difference between the two corridors is the extent to which they create new linear patterns. A totally new corridor across farms and undissected landscape is created by route A. In contrast, corridor F takes advantage of existing corridors over a sizable portion of the route. Althouth this may not be without some drawbacks, it certainly is less limiting on future land use.

9.2 Adverse Impacts Which Cannot Be Avoided

Transmission lines or other utility facilities have the least amount of environmental impact if careful planning and analysis precede their installation. However, some environmental impacts are impossible to mitigate or avoid simply because of necessary construction operations and the physical presence of the line, irrespective of location.

For example, changes in land use are an unavoidable impact of transmission lines unless the lines can be placed in a previously established corridor which already contains other similar facilities. Even corridor sharing may not be entirely successful in minimizing impact because extra right-of-way is usually required. The preparation of right-of-way has its most drastic, unavoidable effect in forested areas. Vegetation underneath the line(s) is

allowed to reach only a certain maximum height. Therefore, timber resource which is lost will never be allowed to grow beyond a certain height again. Somewhat lesser degrees of change or impact are inevitable when a transmission route crosses any area of land not previously used for that purpose. Irrigated lands are especially sensitive in this respect within the study area although the degree of impact may be minimized.

Some loss of soil is an unavoidable impact of construction which often results in increased sedimentation load in nearby streams. With construction of access roads and staging areas, as well as the tower foundations, some reshaping of the landscape is inevitable. This may also create practical problems with land restoration, and effective reclamation may be unpredictable at best. Also, given inadequacies of knowledge and the fallibilities inherent in man, almost all other conceivable geologic impacts may occur. Nevertheless, the potential for these impacts is partially minimized by adherence to terrain which requires the least excavation.

Construction and removal of vegetation both result in unavoidable loss of habitat for wildlife. Another, and perhaps more serious, impact is the increased number of access roads, some of which may follow the transmission line into previously unpenetrated wildlife areas.

Other impacts inherent in transmission line operation are audible noise and interference with radio and television reception within the immediate area. Although a lesser degree of impact may be considered directly proportional to a lesser number of

people inconvenienced by these effects, their existence must be acknowledged.

The visual impact of transmission lines is one of the most often mentioned impacts which cannot be avoided. However, the impact is highly variable and also somewhat subjective. Some individuals may consider the impact to be minimal if a transmission line cannot be seen from the highway. Others, who prefer lines in already established corridors, would discourage lines placed in a more natural, untravelled area. Thus, the visual or aesthetic impact of a transmission line cannot be quantified, but it will undeniably exist.

9.3 Irreversible and Irretrievable Commitments of Natural and Cultural Resources

The construction and operation of a transmission line involves the irreversible commitment of both material and energy. In this respect it differs little from most commercial activity. However, it differs strongly from most other types of human activity because of the side effects (often difficult to quantify) which it has on the area it crosses.

The usual commitment of resources is the actual building material, the energy required for fabrication and transportation and the human energy input for planning, preparation and construction. It is this commitment of resources that the builder is most cognizant of, since these resources represent direct costs to the company. The more abstract, non-market resource costs are the ones that make the building and operation of a transmission line somewhat unique.

Any transmission line will have significant land use implications, if for no other reason than the amount of land crossed. Some of these effects, listed below, are for all practical purposes irreversible.

1. The land used for the tower foundations and maintenance or access roads is irreversibly lost to its natural state (i.e., as forest resource or wildlife habitat). It is possible that the transmission line could be removed and the land allowed to go back to nature. However, such an occurrence is unforeseeable at this time.

2. Maintenance or access roads will create irreversible effects on wildlife because of increased usage of those areas by humans.

3. Visual impact in some areas will be particularly severe. Not only will the line dominate the landscape in some areas, even to the casual observer; but for life long residents, vistas which are unique to them will be fundamentally changed.

4. There may be one basic irretrievable commitment placed upon the Yellowstone River. The Yellowstone is a unique natural resource, due to its wild, free-flowing characteristics. This river has a great potential for inclusion in either a national or state Wild and Scenic Rivers System, largely because of its lack of development, especially in its lower reaches downstream from Billings. There are relatively few roads, residences or utility lines visible from the river in this area. Thus, the crossing of the river by a major transmission line is a significant mark against the wildness of that reach of stream. The

transmission line thus represents a diminished potential for protection of the scenic, free-flowing nature of the river.

The ultimate irreversible - irretreivable commitment of our resources comes when we finally begin to limit our options for maintaining the kind of environment we want to live in. This question of prioritites may confront us very soon in such areas as the lower Yellowstone River.

9.4 Relationship Between Local, Short-Term Uses of Man's Environment and Long-Term Effects

The relationship between man's short-term uses of the environment and long-term effects is essentially cumulative in nature. A transmission line will have a number of predictable, immediate impacts upon the environment, i.e., soil loss, vegetation removal and change in land use. However, in one form or another both the environment and man will adapt to the changes. Roads may be built where wildlife habitat was once undisturbed; the corridor or right-of-way may cut through land which was covered by unbroken forest; and farmers and ranchers may have to readjust their irrigation and crop patterns to accomodate the presence of the transmission line. The area in the immediate vicinity of the line will never be exactly as it was before.

The long term effects of these impacts are difficult to establish in terms of one transmission line. It is the cumulative impact of many lines and additional development which begins to suggest what the long term effects might be. Any assessment of

these effects can only begin with evaluation of a specific transmission line proposal as it fits within the broader perspective of our society's future.

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GLOSSARY

ACSR - Aluminum Conductor-Steel Reinforced. Conductor has a steel core around which the aluminum wires are stranded. The numbers are identified by MCM ACSR.

ALTERNATING CURRENT - Current that reverses at regularly recurring intervals of time and has alternating positive and negative values.

CIRCUIT - Conductor or system of conductors through which an electric current is intended to flow. (In an A.C. system, one circuit has three phases and each phase has one conductor or bundle of conductors).

CONDUCTOR - A wire or combination of wires (bare or insulated) suitable for carrying an electric current.

CONDUCTOR, BUNDLE - Two or more conductors per phase.

CORONA - Electrical discharge caused by ionization of air near a high voltage conductor. Sharp edges, points, abrasions, etc., precipitate discharge causing radio and TV interference. Extreme care in handling large conductors is required to avoid damage. All hardware is designed to eliminate as much corona as possible.

CURRENT - Is measured in amperes and can be compared to the amount of flow in a waterpipe. A 100-watt light bulb in a 110-volt line draws about .9 amperes. A typical residence utilizes a 100-amp capacity service entrance, through only a fraction of this capacity is generally used.

DIRECT CURRENT - Unidirectional current in which changes in value are either zero or so small that they may be neglected.

DOUBLE CIRCUIT - Two separate single circuits strung on one tower structure.

GUYING - Galvanized steel cable used for supporting transmission towers.

INSULATOR, SUSPENSION - A bell shaped object made of a nonconducting material such as porcelain, glass or plastic used to suspend the conductor from the tower or structure. Main parts consist of hub - upper part made of metal; skirt - middle section made of insulating material; cobb - lower metal portion. Cobb connects to hub of next insulator in a string.

KILO - Prefix used when speaking of larger values of voltage, power and energy. A kilovolt (KV) is 1000 volts, a kilowatt (KW) is 1000 watts, and a kilowatt-hour (KWH) is 1000 watt hours.

MINIMUM GROUND CLEARANCE - The least distance that a conductor is allowed to approach the ground level under design loading conditions. These distances are:

33 KV	22 ft.
69 KV	23 ft.
115 KV	25 ft.
230 KV	30 ft.
287 KV	31 ft.
345 KV	32 ft.
500 KV	35 ft.
750 KV d-c	35 ft.

PHASE (ALTERNATING CURRENT) - One wire of a three wire alternating current system, designated as A, B, or C.

SINGLE CIRCUIT - A circuit with three phases and three conductors (or bundles of conductors) on one tower structure.

SHIELD WIRE - Special grounded conductors used for reducing the voltage from electric or magnetic induction; Also used for grounding purposes on top of transmission line towers.

VA-MVA - Unit of energy measured in volt/amperes or megavolt/amperes 1 MVA = 1,000,000 VA.

VAR-MVAR - Unit of reactive power, 1 MVAR = 1,000,000 VAR.

VOLTAGE - The force which drives the electrical current. It can be compared to pressure in a waterpipe. Line voltage in a house is usually around 110 volts.

WATT - Is a unit of power and is a function of the voltage and current in the system. It is comparative to the total amount of water coming from a pipeline. A watt is equivalent to one amp of current under a pressure of one volt. A common household light may run from 25-200 watts. The watts being consumed is the rate at which electrical energy is being supplied. If one uses electricity at a rate of one watt for one hour, he has consumed one watt-hour of electrical energy.

Appendix A

GEOLOGY

Geologic History

The generalized, decipherable geologic history of Montana, from a time somewhat greater than one billion years ago (the Precambrian Era) was one of intermittent, deep crustal subsidence and sedimentary accumulation in western and central Montana, and thinner, interrupted sedimentation elsewhere. Subsidence and accompanying sedimentation have alternated with periods of uplift and erosion, and where sedimentation has been thickest, the greatest uplift has occurred, resulting in the formation of mountains.

By late Jurassic time (150 million years ago), a mountain belt that extended along the western margin of Montana was seperated from the eastern portion of the continent by a narrow seaway which was continuous from the present Arctic Ocean to the Gulf of Mexico. The waters of the seaway regressed and returned along this course a number of times during the Cretaceous Period (about 100 million years ago), partly due to periodic, regional subsidence or uplift and partly due to eustatic sea level changes. Each regression or transgression left decipherable geologic evidence in the form of erosion or deposition of sediments (Colorado group, Telegraph Creek formation, Eagle sandstone, Claggett shale, Judith River formation, Bearpaw shale.

With deposition of the marine Bearpaw shale, the seas retreated from this part of North America for the last time. The Powder River region began to subside as a localized sedimentary basin, possibly as a result of initiation of stresses which marked the beginning of the new Laramide mountain building period, which had its most widespread effects further west (Wyoming Geological Association (WGA), 1965). The Bull Mountain region had already been an active sedimentary basin since early Cretaceous time. Amid an environment of flood plains, meandering streams, and coastal plains (WGS, 1965), 1,000 to 1,500 feet of the Hell Creek formation was deposited.

As Laramide mountain building intensified in western Montana and in the Big Snowy, Bighorn, and Black Hills regions, the study area slowly evolved to its approximate present structural geometry. During early Cenozoic time, coal swamps became extensive in the Bull Mountain and Powder River regions. Into this swampy, floodplain environment were introduced the sands and clays, which, together with coal, make up the Tongue River formation.

The remaining geologic history of the study region is primarily erosional, although middle Cenozoic to Recent stream deposits are locally preserved on some of the higher plateaus and terraces.

Structure

Except locally, as near the Bighorn and Snowy Mountains, the sedimentary rocks in the study area lie in nearly horizontal layers. However, on the large scale the strata are warped into a number of domes, basins, synclines, and anticlines which are nearly imperceptible to the eye. These are most evident on small-scale geologic maps (Geologic Map of Montana, 1955), because erosion exposes older strata within domes and anticlines and preserves younger strata within synclines and basins.

Prominent structural features of the study region include the Big Coulee dome west of Broadview, the Porcupine dome north-west of Forsyth, the Big Horn Mountains uplift south of Billings, Big Snowy uplift north of Ryegate and the Bull Mountain and Powder River Basins. The Bighorn and Big Snowy uplifts differ from the other domes primarily in having much greater structural relief. The oldest rocks found in the study area are exposed within these uplifts.

The Lake Basin - Huntley zone of an echelon normal faults extends for about 70 miles through the study area, from about 9 miles west of Acton to a point about 8 miles northeast of Hardin. These faults locally have caused great disorder among the otherwise flat-lying beds.

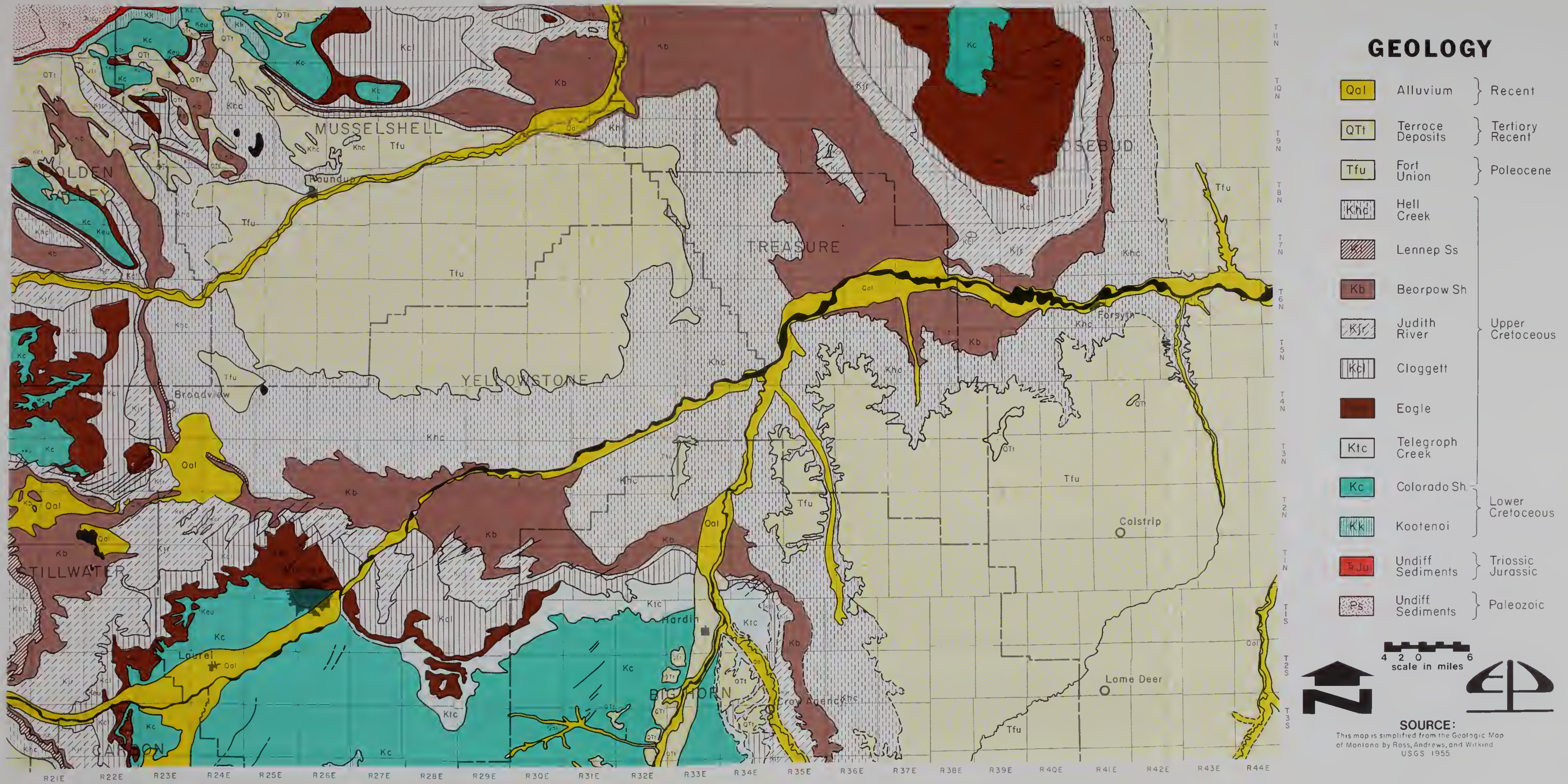
Additional smaller and less pronounced domes, basins, anticlines, and synclines are scattered throughout the area. Several notable anticlines are very evident in the field because they have local, steep bedding dips and contain some prominent resistant layers. They are the Woman's Pocket and Devils' Basin, west and north of the Bull Mountains Basin, respectively.

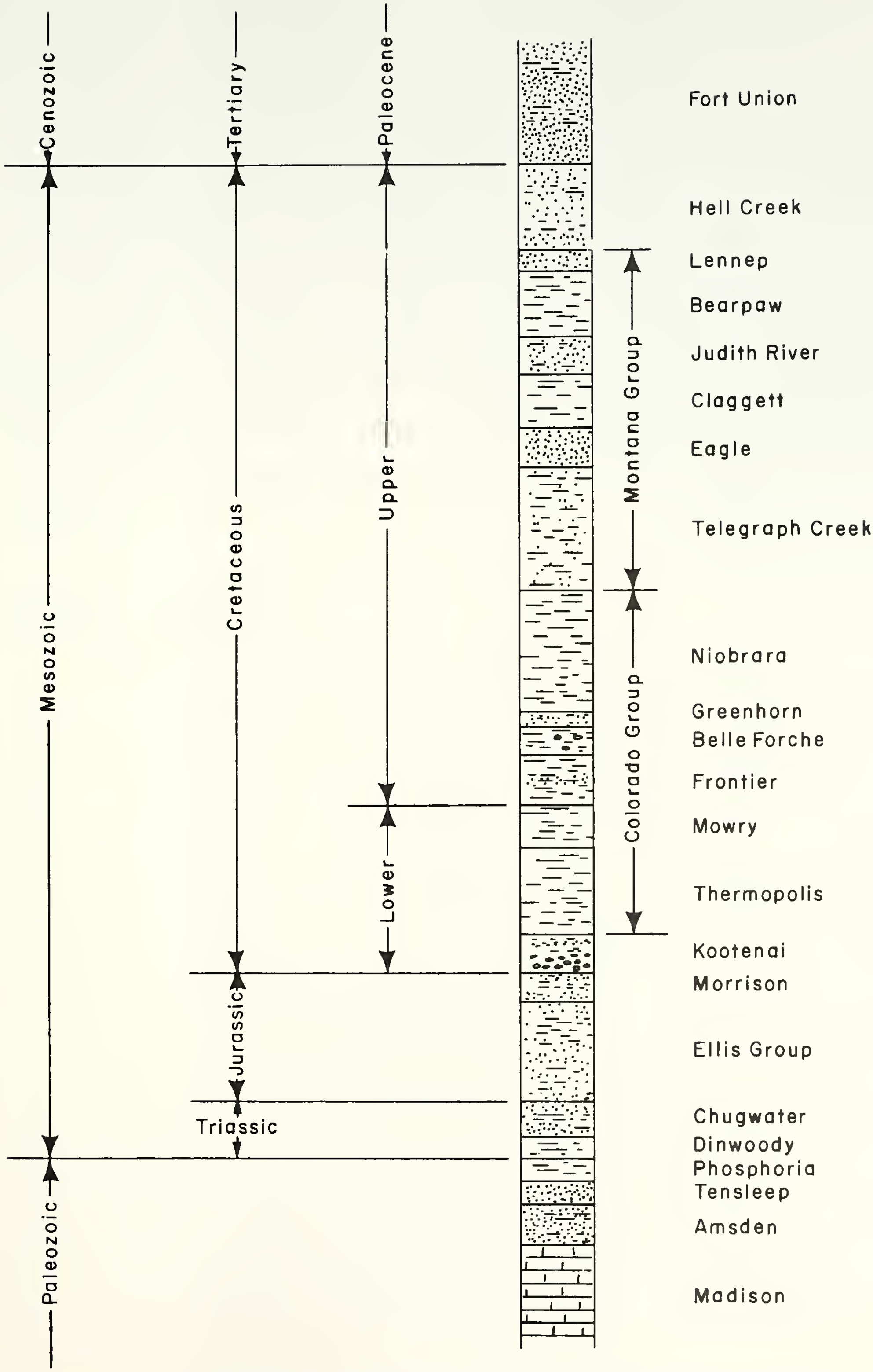
With the exception of the Lake Basin-Huntley fault zone, where surface faulting is apparently a manifestation of deeper horizontal crustal movements (Chamberlin, 1919), all other structures are mainly the result of differential vertical movements of the earth's crust (Norwood, 1965).

Two peculiar physiographic basins of structural origin lie within or adjacent to the study area. They are the Comanche Basin, southeast of Broadview, and Lake Basin, to the southwest. Although younger beds have been eroded from these areas, they now have no stream drainage outlets. Evidently the basins were formed in relatively recent time, due to epeirogenic crustal movement that occurred at a rate greater than the pre-existing drainage systems could cut downward.

Stratigraphy

All exposed rocks in the study area are of sedimentary origin ranging in age from Mississippian to Recent (about 340 million years ago to the present). These rocks are the residue of past environments in which deposition was taking place. By understanding something of the rocks and the sequence in which the strata occur, we can learn a portion of the history of this region during


GEOLOGY
Qal Alluvium } Recent
QTt Terrace Deposits } Tertiary Recent
Tfu Fort Union } Paleocene
Khc Hell Creek
Kl Lennep Ss
Kb Bearpaw Sh
Kjr Judith River
Kcl Claggett
Eagle
Ktc Telegraph Creek
Kc Colorado Sh.
Kk Kootenai
Upper Cretaceous
Lower Cretaceous
TrJu Undiff Sediments } Triassic Jurassic
Ps Undiff Sediments } Paleozoic
4 2 0 6
scale in miles
SOURCE:
This map is simplified from the Geologic Map of Montana by Ross, Andrews, and Witkind USGS 1955
MUSSELSHELL
GOLDEN VALLEY
Roundup
TREASURE
ROSEBUD
YELLOWSTONE
Broadview
Forsyth
Colstrip
STILLWATER
Laurel
Hardin
BIGHORN
Crow Agency
Lame Deer
CARBON
R21E R22E R23E R24E R25E R26E R27E R28E R29E R30E R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E
T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S



GENERALIZED STRATIGRAPHIC COLUMN OF STUDY AREA

Figure A1

the past 300 million years. The record is incomplete and always difficult to decipher. Periods of erosion and non-deposition are represented by hiatuses in the rock sequence which tell us little of the environments which existed during those times.

Many of the rocks in the study area were deposited in marine environments and others are the deposits of large deltaic regions, perhaps similar to the present Mississippi delta. During this time interval, climates changed, seas advanced across the area and retreated, basins formed and filled, and the Rocky Mountains formed.

Paleozoic Sediments

Palezoic rocks crop out in a small region in the northwest corner of the study area in the Big Snowy Mountains. There the Upper Paleozoic consists of several formations. The Madison group is Mississippian in age (300 -340 million years) and consists of about 1,800 feet of predominently marine limestone. The Big Snowy group unconformably overlies the Madison in the Big Snowy Mountains and consists of shallow water deposited sandstone and red shale near the base of the group to dark limestone and shale near the top (Norwood, 1965). The Amsden group unconformably overlies the Big Snowy group (Mississippian) and is Pennsylvanian (250 -300 million years) in age. The Amsden consists of up to a couple of hundred feet of sand and shale. The Tensleep sandstone crops out south of the study area and makes up a significant portion of the Paleozic rocks (Norwood, 1965). The Phosphoria

formation makes up the youngest of the Paleozoic rocks. These two formations occur at depth in the study area, but do not crop out. The Paleozoic rocks (not each formation) underlie the entire study area.

Triassic and Jurassic Sediments

Although rocks of Triassic and Jurassic age underlie most of the study area, they crop out in only a small area. The Triassic was a time of erosion in the Big Snowy Mountain area and only Jurrassic rocks are present (Norwood, 1965). Triassic rocks crop out south of the study area and probably underlie parts of it.

Cretaceous

Kootenai

The Kootenai is Lower Cretaceous (100-135 million years) and consists of a variable thickness of conglomerate, coarse sandstone and shale of fluvial origin (Thom, et al., 1935). Thom et al. reports measured thicknesses for this unit of 146 and 185 feet. A measured section near the Wyoming border (south of the study area) included seven feet of coal in a local bed.

Colorado Group

The Colorado group consists of Lower and Upper Cretaceous shale that crops out mainly in the Billings and Porcupine dome

areas. It is about 2,000 feet thick within the study area, and is made up almost exclusively of gray and black, soft, easily weathered shale. Where well exposed, the Colorado group may be separated into a number of distinct, but similar formations. Weathering and geomorphic characteristics of the shale cause it to form gently rolling areas of low relief and gentle slope throughout most of its outcrop area. Near Billings, Recent meandering of the Yellowstone River has cut deeply into Colorado shale which has created local badlands. Colorado shale becomes plastic and sticky (gumbo) when wet, making vehicular traffic difficult or impossible during rainy weather.

Telegraph Creek Formation

The Telegraph Creek formation contains sediments which are transitional between the underlying Colorado shale and the overlying Eagle sandstone. Where exposed near Hardin this formation contains 320 feet of light-colored sandy shale with a thin, resistant, concretionary sandstone near its middle (Thom, et al., 1935). Near Billings, Nappen and Moulton considered the sandstone to represent the base of the Telegraph Creek formation and measured about 160 feet of thickness. This formation is difficult to distinguish physiographically from the Colorado shale. Near Billings, the Telegraph Creek formation is commonly concealed in the talus slope that lies beneath the prominent, cliff-forming Eagle sandstone.

Eagle Sandstone

In the western portion of the study area this sandstone is about 240 feet thick, massive near its top and bottom, and slightly shaley and thin bedded in the middle (Hancock, 1918). The formation thins eastward, and is not present in the vicinity of Hardin. Where it crops out along coulees and valleys, the Eagle sandstone forms high, yellowish gray cliffs, typically displayed in the Billings rimrocks.

Claggett Formation

The Claggett formation overlies the Eagle sandstone in the western portion of the study area, and eastward, where the Eagle disappears, it rests directly on the Telegraph Creek formation. The Claggett formation is a dark marine shale, about 500 feet thick near Hardin (Thom, et al.,1935). The Claggett contains a few thin sandstone beds which locally form low escarpments. Claggett terrane tends to be subdued, relative to the Eagle and overlying Judith River sandstones.

Judith River Formation

The top of the Judith River formation is composed of about 20 feet of hard grayish-white sandstone which is more resistant than adjacent strata. Beneath the sandstone, the formation consists of a brown sandy shale. Fossilized marine invertebrates evidence a marine origin of these rocks (Dobbin, 1929).

Bearpaw Shale

The Bearpaw shale consists of 600 to 1,000 feet of dark blue to gray black marine shale with little or no sandstone. It forms extensive areas of subdued relief, especially surrounding the Porcupine dome and north and northeast of Billings. At the top of this interval is a transitional zone 20 to 60 feet thick (Dobbin, 1929 and Renick, 1929) which is believed to be the last marine sediments in Montana (Dobbin, 1929). The shale contains abundant calcareous concretions some of which contain marine invertebrate fossils (Dobbin, 1929). This unit also contains commercial amounts of bentonite.

Lennep Sandstone

The Lennep sandstone is present only in the western portion of the study area. There it contains a massive, light colored lower sandstone member and a brown, andesitic upper sandstone with a total thickness of up to 350 feet (Hall and Howard, 1929). It typically forms a prominent escarpment above valleys formed in Bearpaw shale.

Hell Creek Formation

Overlying the Lennep sandstone in the west and the Bearpaw shale in the east, the Hell Creek formation consists of about 675 feet (Hall and Howard, 1929) of fresh-water, lenticular sandstone with interbedded shale. It forms rough landscapes of buff colored rock.

Cenozoic

Fort Union Formation

The Fort Union formation is the youngest (about 60 million years) bedrock unit exposed in the study area and is of particular interest because it contains coal. It is separated into three members. Although they differ notably in character, they are not distinguished on the geologic map.

The lowest member is about 250 feet thick (Rogers and Lee, 1924) and is known as the Tullock. It differs from the underlying Hell Creek formation mainly in the presence of thin coal beds. It also contains sandstones that are more massive and laterally pervasive, resulting in prominent cliffs. The Geologic Map of Montana (1955), from which the geologic map of the study area was taken, included the Tullock member in the Hell Creek formation in the area surrounding the Bull Mountains.

The middle Fort Union member is the Lebo shale with an average thickness in the study area of about 175 feet (Renick, 1929). The Lebo is easily recognized on the basis of its color, which includes various shades of grey, and the fact that where it is exposed, it tends to form badlands. Where vegetated, it forms broad areas of subdued, rolling topography. Local ranchers occasionally experience severe road maintenance problems where this member occurs.

The overlying Tongue River member contains all of the thick coal beds in the region. Although its youngest portion has been removed by erosion, it is over 1,680 feet thick (Dobbin, 1930). This member contains sandstone, shale, carbonaceous shale and

some thin, fresh water limestone beds in addition to the coal. Much of the coal has burned *in situ*, a result of prehistoric lightning or range fires. The heat of burning has fused and altered surrounding beds, coloring them mostly red and yellow. These layers are resistant to weathering and often form prominent, red-capped buttes.

Resistant Tongue River beds locally produce some of the highest and most rugged topography in the entire study area, such as in the Little Wolf Mountains.

Recent

Terrace Gravels and Alluvium

Various isolated plateaus and river terraces in the area are covered by layers of gravel, relics from times when ancient rivers flowed over them. The highest of these gravels is as much as 1,200 feet above the present level of the Yellowstone River and may date from the Oligocene (25-40 million years ago) (Alden, 1924). The lowest gravels, on the other hand, are relatively recent features, perhaps Pleistocene (two million years or less) (Alden, 1924). Because of its high permeability, gravel tends to inhibit runoff, and thereby serves to protect the tops of these terraces and plateaus from erosion.

Comanche Basin

Comanche Basin is floored with a thick deposit of fine grained sediment that has been washed in from the surrounding

hillsides. This material is mainly clay which turns to gumbo when wet, making vehicular traffic over it nearly impossible.

Economic Geology

Coal

The subbituminous and lignite deposits of Montana, Wyoming, and the Dakotas represent one of the largest coal deposits in the world. Although the coal within the study area is but a small fraction of the deposits in the four state area, it is presently the study area's most important economic mineral commodity. This situation is likely to remain the case for some time unless major new discoveries of other minerals are made or coal should lose its present economic status. However, the recent shortages of petroleum products, the hazards involved in dependence upon foreign sources of oil, and the recent changes in federal policy regarding increased reliance upon coal will, no doubt, maintain the value of Montana coal for many years to come.

Major coal deposits in the study area exist only in the Fort Union formation which occurs in the Powder River basin and the Bull Mountains. Coals in the Cretaceous rocks within the study area tend to be thin, of poor quality, and of no economic importance at this time.

Powder River Basin

Although coal beds exist in the older units, the Tongue River member of the Fort Union formation contains the only

economically valuable coals. The Wright bed occurs at the base of the Tullock member of the Fort Union formation. This coal has been mined in the past to supply local needs in Forsyth (Dobbin, 1929). In places where it was mined, this bed ranges from three to four feet in thickness. Along Armell's Creek it ranges from a foot or less to about three feet, and in places it splits into two seams a number of feet apart (Dobbin, 1929).

The Hambre bed occurs about 200 feet above the Wright in the Tullock member and consists of an average of three feet of coal, carbonaceous shale, and carbonaceous sandstone.

The Lebo shale member contains the Big Dirty bed at its base. The Big Dirty bed ranges in thickness from 3 to 13 feet and usually consists of only a small amount of clean coal. Along the East Fork of Armell's Creek the bed contains 6 to 11 feet of fair grade coal but this amount is unusual (Dobbin, 1929).

The Wright, Hambre, Big Dirty, and other smaller beds occurring in the Tullock and Lebo shale member are not economical coal deposits by today's standards.

In the vicinity of Colstrip, the Burley bed occurs about 130 feet above the base of the Tongue River member and is the lowest of the valuable coals. In Section 24, T3N, R41E, this seam contains about five feet of coal. A maximum measured thickness for this bed is 9½ feet near the eastern edge of the study area (Pierce, 1936). The thickness of the Burley bed is variable, though, and is less than two feet thick in the adjacent township.

North of Colstrip along the East Fork of Armell's Creek, the average thickness is about four feet (Dobbin, 1929). The Burley bed constitutes a potentially economic resource in the area north and northeast of Colstrip, although the Department knows of no plans to mine this bed.

The Robinson bed lies about 43 feet above the Burley in the vicinity of Colstrip. East of the East Fork of Armell's Creek in T2N, R41E, the bed is from 2½ to 8 feet thick (Dobbin, 1929). East of Colstrip, the Turret bed occurs at about the same horizon as the Robinson bed. The Turret thickens to the east from less than 18 inches west of Rosebud Creek to an average of 12 feet along the Rosebud-Tongue River Divide (Pierce, 1936). Along Sarpy Creek, the Robinson bed lies 100 to 150 feet above the base of the Tongue River member and is about 20 feet thick (BIA,1973). Here, the Robinson bed will be mined along with other beds overlying it at the Westmoreland Resources mine.

West of Colstrip, the Stocker Creek bed crops out about 130 feet above the Robinson bed. This bed is about 6 feet thick in T2N, R40E. A maximum thickness of this bed was reported by Dobbin (1929) to be 9 feet just west of Rosebud County.

The McKay and Rosebud seams are the most economically valuable coal beds within the study area. The Western Energy mine at Colstrip produced some 5.5 million tons in 1972 from the Rosebud bed. The Peabody mine south of Colstrip mined a total of 1.6 million tons from both seams during 1972. Coal from the

McKay and Rosebud seams is sold to eastern utility companies. The Rosebud coal is also burned in the Corette plant in Billings and will be used to fire Units 1 and 2 at Colstrip. If Units 3 and 4 are built, they, too, will be supplied from the Western Energy mine. The company plans to extend the mine to exploit the Rosebud bed to the northeast, southwest, and west of the town of Colstrip. Production from this mine is expected to reach 19.3 million tons per year by 1980. (By comparison, the largest coal mine in the U.S. had a projected production of 8.5 million tons for 1973.)

Westmoreland Resources will mine a seam about 32 feet thick which is referred to as the Rosebud - McKay seam. The stratigraphic relationship between this seam near Sarpy Creek and the two seams near Colstrip is not clear. This mine will begin producing coal in 1974. Production is expected to be on the order of 4 million tons per year from four seams once full operations are under way (BIA, 1973).

The Rosebud bed is the thickest and most widespread coal seam in the eastern part of the study area. It lies about 360 feet above the base of the Tongue River member (Dobbin, 1929, and Kepferle, 1954) and averages 25 feet in thickness in the area west of Colstrip (Matson, 1973).

The McKay bed is thinner and apparently more variable than the Rosebud, and in the Western Energy mine it occurs about 10 to 18 feet below the Rosebud where it is about 8 to 9 feet thick (Kepferle, 1954).

Several other coal beds lie above the Rosebud but have much less economic importance than the Rosebud within the study area. These beds appear south of the outcrop of the Rosebud seam and the town of Colstrip.

Along Tullock Creek, there are several thin beds but these do not appear to be economic deposits. At the Westmoreland mine on Sarpy Creek, two beds, each 3 to 5 feet thick, will be mined. Designated as "stray" beds, these coal seams would probably not comprise an economical deposit by themselves but will be mined with the thicker beds.

Bull Mountain Basin

The Fort Union formation is exposed in the Bull Mountain area, a broad structural basin in the northwest portion of the study area. The Tongue River member is about 1,700 feet thick in the central portion of this area and contains some 26 persistent coal beds and many other lenticular ones.

The Roundup bed, which lies about 500 feet above the Lebo member, has been mined for a number of years. This bed is from four to six feet thick but is somewhat higher in rank than the coals in the Powder River Basin. Roundup coal has a btu content near 11,000 (Gilmour and Dahl, 1967, and Bateman, 1966). The Carpenter bed has also been mined in the Bull Mountain area.

Clinker

Many of the thicker coal beds have burned along their outcrops. This burning mostly occurred prior to the arrival of the white man in the area and is presumed to have been caused by wild fires, lightning, and other natural causes. The process of natural underground coal fires is not well understood, but the burning eventually stops at some point from the original outcrop, possibly when oxygen cannot get to the combustion zone. The heat released during combustion physically (and chemically) alters the sedimentary rocks around the coal, especially above the burned seam. The thermally metamorphosed rocks generally have an orange or red color and are called "scoria" or "clinker". Parts of this clinker were fluid at one point in its history, but the greatest amount was never fluid and the sedimentary texture still exists. Clinker is a brittle, highly fractured rock which is more resistant to erosion than most of the unaltered rock. Within the area of the thicker coal beds, much of the surface is capped by clinker and some of the landforms are the result of this material.

The clinker which occurs in the study area is used locally for railroad ballast and road surfacing material. Small quarries are worked from time to time to extract this material when needed.

Clay

A number of the Cretaceous formations contain large amounts of bentonite, of which some deposits are mined. Bentonite is

the name for a material rich in the clay mineral montmorillonite. It is formed by the alteration of volcanic ash.

Bentonite is used in a variety of ways including pelletizing of taconite iron ore, sealing ditches and dams, drilling muds, filters, and foundry sands, and in the cosmetic and paper industry (Gillson, 1960). Mining bentonite is generally a simple operation. Power shovels and bulldozers are usually employed to remove the overburden and clay.

Within the study area, bentonite is mined north of the Yellowstone River near Vananda. The clay found there is not of the best quality; thus, it is used mostly in taconite processing and drilling muds. The area disturbed by the mining of this commodity and areas designated for future mining are also large. However, the mining area is not spacially continuous.

Sand and Gravel

Sand and gravel industry extraction is the largest mineral industry in the world on a volume basis (Lenhart, 1960). Sand and gravel deposits occur throughout the study area, especially along the terraces of the larger rivers. Sand and gravel pits are generally only a few acres in size. The economic character of a particular deposit depends upon its proximity to a need for the material, since the value of sand and gravel does not make it feasible to transport it for long distances. Increased construction of roads, buildings, and so forth in the study area would increase the demand for sand and gravel and new areas might be mined.

Oil and Gas

Oil and gas are produced within the study area, mainly from a number of small fields in the Porcupine dome area north of the Yellowstone River. A small gas field has also been exploited near Hardin. Three refineries in Laurel and Billings have a combined capacity of about 104,000 barrels per day (DNRC, 1972). However, only part of the crude for these refineries comes from within the study area.

Appendix B

SOILS

Definition of Soil Terms Used

Clay (fine textured) - Soils with more than 45 or 50 percent clay sized particles in their subsoils.

Clayey - Soils with more than 35 percent but less than 45 or 50 percent clay sized particles in their subsoils.

Silty - Soils with less than 15 percent coarser than very fine sand and less than 35 percent clay sized particles.

Loamy - Soils with more than 15 percent coarser than very fine sand and less than 35 percent clay sized particles in their subsoils.

Surface layer - That part of the soil ordinarily disturbed by cultivation, or its equivalent in the uncultivated soil.

Subsoil - All subsurface soil layers between the surface layer and the substratum, if present, regardless of their properties.

Substratum - The materials below the subsoil, such as unweathered bedrock, loose sand and gravel, or other materials that restrict or prohibit root growth.

Soil Descriptions

*Shallow, loamy, and silty, well-drained soils formed from beds of siltstone and loamstone.

Representative Profile:

Surface layer -- a thin, light brownish-gray loam.

Subsoil -- massive, light yellowish-brown, calcareous loam of silt loam.

Substratum -- at a depth of less than 20 inches soft, platy, siltstone and sandstone beds that can be penetrated with a spade but become hard and brittle when dry.

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*soil depth
Deep -- more than 40 inches
Moderately deep -- 20-40 inches
Shallow -- less than 20 inches

Soil textures are loam, silt loam, or clay loam.

This soil occurs in 4A, 4B, 4D, 4E, 5B, and 5C soil associations. (See Section 6.2.3.3)

Shallow, clayey, well-drained soils formed from beds of siltstone and claystone

Representative Profile:

Surface layer -- a light brownish-gray calcareous, silty clay loam.

Subsoil -- a light yellowish-brown, massive calcareous silty clay loam.

Substratum -- at a depth of less than 20 inches soft, platy calcareous beds of siltstone and claystone that become hard when dry.

Clay ranges from 36 to 50 percent.

This soil occurs in 4D, 4E, 5B, and 5C soil associations.

Shallow, well-drained, clay soils that are formed from marine shales.

Representative Profile:

Surface layer -- a thin, weakly calcareous, dark olive clay.

Subsoil -- a blocky, calcareous, pale olive clay.

Substratum -- material grades to hard shale beds at depths of less than 20 inches.

Clays are mainly of the montmorillonitic group. They range from 50 to 70 percent.

This soil is found in 3A and 3B soil associations.

Shallow loamy, well-drained soils formed over consolidated sandstone.

Representative Profile:

Surface layer -- a dark grayish-brown, granular sandy loam.

Subsoil -- a massive, calcareous loam

Substratum -- fractured hard sandstone at depths of less than 20 inches.

Substratum may be noncalcareous. Rock fragments (channery and flaggy) range form 0 to 35 percent.

This soil is a part of 4G, 5A, and 5D soil associations.

Loamy, fragmental, well-drained soils that are shallow to scoria and porcellantic beds.

Representative Profile:

Surface layer -- a thin, light reddish-brown channery loam.

Subsoil -- a massive, reddish-brown very channery loam.

Substratum -- at depths of less than 20 inches hard, platy porcelanite and clinkers coated with calcium and carbonate. Rock fractures contain voids filled with loamy soil material that may extend to a depth of 30 or 40 inches.

Rock fragments range from 30 percent in the surface horizon to 80 percent in the substratum.

This soil is a part of 6A and 6B soil associations.

Moderately deep, sandy loam well-drained soils formed over weakly consolidated sandstone beds.

Representative Profile:

Surface layer -- a thin, hard grayish-brown, granular fine sandy loam.

Subsoil -- a massive, calcareous, light yellowish-brown, granular fine sandy loam.

Substratum -- at a depth between 20 and 40 inches weakly consolidated platy sandstone that becomes very hard, compact and brittle when dry.

This soil is a part of 4G and 4C soil associations.

Moderately deep, fine-loamy, well-drained soils formed over beds of siltstone and loamstone.

Representative Profile:

Surface layer -- a very thin, dark grayish-brown, granular loam or silt loam.

Subsoil -- dark brown, light clay loam, in upper part and massive, calcareous, light olive brown loam, in lower part.

Substratum -- at a depth between 20 and 40 inches olive colored beds of loamy shale and sandstone.

This soil occurs in 4A and 4B soil associations.

Moderately deep, clayey, well-drained soils formed over beds of claystone.

Representative Profile:

Surface layer -- a light brownish-gray, granular loam.

Subsoil -- grayish-brown blocky clay loam in upper part and massive, calcareous, light brownish-gray clay loam in lower part.

Substratum -- at a depth between 20 and 40 inches platy, calcareous claystone beds.

Clays are mainly of the montmorillonitic group and range from 35 to 40 percent in the subsoil and substratum.

This soil occurs in 5D soil association.

Moderately deep, well-drained, clay soils formed from marine shales.

Representative Profile:

Surface layer -- a grayish-brown granular clay.

Subsoil -- massive or blocky, calcareous, grayish-brown heavy clay.

Substratum -- at depths between 20 and 40 inches grades to dark platy shale that becomes extremely hard when dry.

Surface and substratum ranges from 60 to 80 percent clay which is of the montmorillonitic type.

This soil is part of 3A and 3B soil associations.

Moderately deep, clayey well-drained soils, formed from hard sandstone or mixed sandstone and shale beds.

Representative Profile:

Surface layer -- a grayish-brown loam.

Subsoil -- blocky dark brown and yellowish-brown, heavy clay loam in upper part and massive, calcareous, pale yellow, gritty clay loam in lower part.

Substratum -- at a depth of between 20 and 40 inches indurated sandstone and shale beds.

Subsoils range from 35 to 45 percent clay. Clays are of the montmorillonitic type. Substratum contains a few to 20 percent coarse fragments.

This soil occurs in 5A and 5D soil associations.

Moderately deep fine-loamy, well-drained soil formed over hard porcellanite and clinker beds.

Representative Profile:

Surface layer -- a weak blocky, dark brown loam.

Subsoil -- reddish-colored loam extending to the depth of between 20 and 40 inches.

Substratum -- hard fractured beds of porcellanite and clinker. Fractures contain soil material of loam texture.

This soil is part of 6A and 6B soil associations.

Deep, fine-loamy, well-drained soils formed in loamy alluvium of bottomlands, fans and stream terraces.

Representative Profile:

Surface layer -- granular, grayish-brown loam.

Subsoil -- a blocky, light brownish-gray and brown loam in upper part and massive, calcareous pale brown loam that extends to a depth of 60 inches or more.

Some flood plains and fans soils are not well developed. They lack subsoil horizons and are stratified in the lower substratum with sandy loam or loamy fine sand.

This soil makes up part of 1A soil association.

Deep, well-drained sandy loam formed soils in sandy loam alluvium or bottomlands, fans and stream terraces.

Representative Profile:

Surface layer -- a granular, weakly calcareous, light brownish-gray sandy loam.

Subsoil -- massive, weakly calcareous, stratified, light brownish gray sandy loam extending to the depth of 60 inches or more.

Stratified material include fine sandy loam, loamy sand or sand.

This soil occurs in 1A and 4C soil associations.

Deep, well-drained, clayey soils formed in clay loam or silty clay loam alluvium on the bottomlands and fan terraces.

Representative Profile:

Surface layer -- granular, light olive gray clay loam.

Subsoil -- massive stratified, calcareous, light olive gray clay loam that extends to the depth of 60 inches or more.

All horizons are usually calcareous and are stratified with loam and silty clay loam. Clays range from 35 to 45 percent and are of the montmorillonitic type.

This soil makes up part of 1A, 2A, and 4F soil associations.

Deep, well-drained clay soils formed in fine-textured alluvium on the fans and terraces.

Representative Profile:

Surface layer -- a granular, dark grayish-brown clay.

Subsoil -- massive, weakly calcareous, dark gray clay that extends to 60 inches or more.

Clay ranges from 45 to 60 percent in the subsoil and is of the montmorillonitic type.

This soil is part of 3A soil association.

Deep, saline or sodic soils formed in clay sediments on fans, flood plains and basins.

Representative Profile:

Surface layer -- a thin, fragile, massive, grayish-brown clay.

Subsoil -- blocky, grayish-brown clay in upper part and massive olive gray clay in lower part containing threads and spots of gypsum and other salts, extending to 60 inches or more.

The soil is strongly alkaline. Below the surface layer clay ranges from 45 to 60 percent and is of the montmorillonitic type. Within local landscapes of this soil, it might include profiles of white silt-coated, crusted, barren surface layers and salt flocculated granular horizons beneath the very thin clay subsoil.

This soil is part of 1B and 1C soil association.

Deep, well-drained, sandy loam soils formed in mixed outwash sediments on the high terraces.

Representative Profile:

Surface layer -- a granular, dark grayish-brown loam.

Subsoil -- massive, strongly calcareous, brown, very gravelly fine sandy loam that extends to 60 inches or more.

Horizons below 30 inches contain from 40 to 60 percent by volume of gravel fragments.

This soil occurs in 2D soil association.

Deep, well-drained, clayey soils formed from clay loam or silty clay loam sediments on the high terraces.

Representative Profile:

Surface layer -- a granular, dark grayish-brown, light silty clay loam.

Subsoil -- blocky, dark brown light silty clay loam in upper part and blocky to massive, very calcareous, olive brown silty clay loam extending to a depth of 60 inches or more.

Clays range from 35 to 45 percent in the subsoil. The substrata is less calcareous below 30 inches.

This soil makes up part of 2A soil association.

<u>Deep, well-drained clay soils formed in fine textured sediments on the high terraces</u>.

Representative Profile:

Surface layer -- a granular, dark grayish brown clay.

Subsoil -- blocky grayish-brown clay in upper part and massive, calcareous olive clay in lower part that grades to a clay loam horizon at a depth of about 32 inches. This extends to a depth of 60 inches or more.

The subsoils become less calcareous below 30 inches. Clays range from 50 to 60 percent in the subsoils and are of the montmorillonitic type.

This soil occurs in 2B soil association.

GROUP 1 Soils of the Stream Valleys (labelled "Soils of the valleys" on General Soils Map)

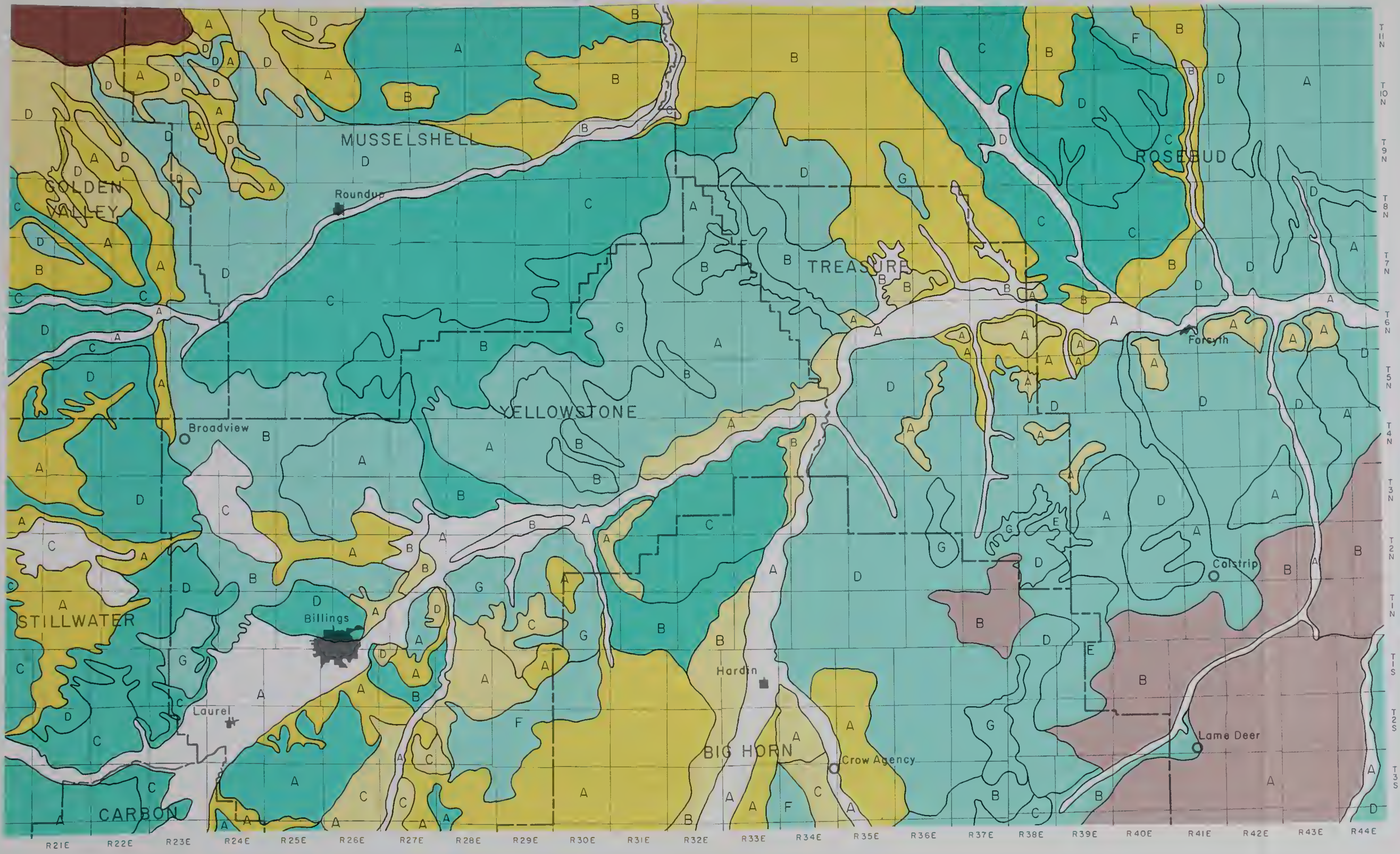
1A. This is a grouping of soil associations in major stream valleys and the narrow valleys of tributaries. These soils are derived from alluvial depositional material. Textures range from the loamy, clayey and clay soils on nearby level to sloping (0-8%) fans, footslopes and terraces to the sandy loam soils on level bottomlands and low terraces. Generally these soils are deep, well drained and nonsaline. Small areas of seeped and saline soils occur on the bottomlands and terraces and may limit revegetation potential.

1B. This association consists of deep, saline-sodic clay soils on nearly level to sloping fans, footslopes, terraces and uplands. Slope is predominantly less than 4%, with some footslopes and terraces approaching 10%.

1C. This association consists of the deep, well-drained saline-sodic clay soils on the level to gently sloping (less that 4% slopes) fans and terraces. Heavy clay soils are in the flat, undrained basins and depressions where water ponds form for varying periods of time. These soils make up about 90% of the composition. The other 10% is made up of nonslaine loamy to clay soils on well-drained fans and terraces.

GROUP 2 Deep and moderately deep, well-drained soils of the high and intermediate gravel capped benches and terraces. (labelled "Soils of the high benches" on General Soils Map)

2A. This association consists predominantly of soils on high terraces and fans with less than 7% slope; texture is generally clayey to loamy. There are distinct inclusions of hilly, gravelly



GENERAL SOILS

Soils of the valleys

Soils of high benches

Soils on heavy clay shales

Soils on weakly consolidated sandstone and siltstone

Soils on hard sandstone or mixed sandstone and shale

Soils on scoria

Mountainous land

Note: Letters denote soil associations within the general soil classifications. Refer to section 6.2.3.

4 2 0 6
scale in miles

N

SOURCE:
SCS 1974

lands and shallow soils weathered from sandstone and shale on the steep terrace edges and sides of deep valleys and drainageways. Slopes in these soils range from 20% to more than 50%.

2B. Soils in this association occur on the high terraces along the Yellowstone Valley. These are clay textured soils; in Yellowstone County, the nonsaline and nonsodic soils make up 90% of the unit, but in Treasure County only 25%, with sodic soils the main constituent. Slopes are generally less than 3% with rough, broken terrace edges of more than 20% slope also occurring; soils on these terrace edges show a high coarse fragment content.

2C. This is another mixed association dominated by deep clayey soils on nearly level to undulating (less than 8% slope) crests of low mountians, convex slopes and along deep drainageways. Small areas of clay soils, gravelly soils and some loamy soils also occur in this unit. Some steep and very steep terrace edges with dissecting drainageways present shallow soils.

2D. This association occurs on the nearly level to gently sloping (less than 4% slope) high terraces and broad, coalescing, piedmont out-wash fans north of the Musselshell River. Strongly calareous, loamy soils dominate this association. Approaching the Snowy Mountains, these soils have thicker and darker colored surfaces, reflecting higher rainfall associated with higher elevation.

Shallow soils over sandstone and shale are on the steep eroded terrace edges and on the valley walls of the narrow drainageways that dissect these terraces. Slopes range from 20 to over 65%.

GROUP 3 Moderately deep and shallow clay soils formed from shales on the undulating to hilly sedimentary uplands. (labelled "Soils on heavy clay shales" on General Soils Map)

3A. Soils in this association occur on the undulating and rolling broad ridges and on the mid and lower parts of the slopes below the narrow crests. Outcrops of shale occur on the very steep and rough broken areas. Soil texture is clay throughout this association; slopes range from 4% to 15%, with the less extensive shallow soils on slopes of 10% to 45% on narrow, convex ridges and the sides of deep, narrow drainageways.

3B. This association consists of saline and saline-sodic clay soils, separated from association 3A because of lower productivity and more severe limits on revegetation potential. Some of these soils on the fans and terraces are nearly or entirely barren of vegetation.

GROUP 4 Moderately deep and shallow soils formed from weakly consolidated siltstones and sandstones on the undulating to very steep and rough broken sedimentary uplands.

4A. This association consists of a dissected sedimentary upland plain with winding valleys and drainageways separated by knolls and ridges of varying widths. The streams have cut valleys that are 1/8 to 1/4 mile wide and 50 to 150 feet deep below the highest ridges. These valleys have been filled with deep deposits of alluvium on fans, footslopes, and narrow terraces. Shale outcrops and thin sandstone ledges are not uncommon on the steeper sidewalls of the deeper valleys.

The moderately deep silty and loamy soils are on the undulating to rolling broad ridges and on the sides of the shallow drainageways. Slopes are 4 to 20%.

The shallow loamy soils are on the tops of the narrow convex crests and knolls associated with the moderately deep soils, and on the steeper and more dissected parts of the landscape. Slopes range from less than 10% to more than 40%.

Deep loamy textured soils are on the alluvium fans, footslopes, and terraces within the stream valleys. They are on slopes of less than 15%.

4B. This association is made up of moderately deep to shallow loamy and silty soils formed from weakly consolidated siltstones and loamstones. Slopes are generally less than 10% for the moderately deep loamy soils; slopes range from 10% to 25% for the other types. The area of this association in Big Horn County has annual higher precipitation with resulting darker colored surfaces and higher productivity.

4C. This association is predominantly moderately deep to deep, fine sandy loam soils on the undulating to hilly sedimentary uplands, and in swales and valleys where deposits accumulate. Slopes in the latter areas are generally less than 4%.

4D. This association consists mainly of steep, rough broken and deeply dissected sedimentary uplands. The principal soils are the shallow loamy and the shallow clayey soils formed from the weakly consolidated siltstones and mudstones, primarily of the Fort Union and Hell Creek formations. Slopes range from 15 to more than

70%. Many of the slopes facing south and west are barren or nearly barren and almost vertical. Outcrops of siltstone or sandstone are common. Lesser areas of moderately deep silt and clayey soils, deep gravelly, loamy and clayey soils also occur on slopes less than 15%.

4E. This association occurs at the upper reaches of several converging drainage systems where the weakly consolidated Fort Union and Hell Creek formations have been severely eroded and dissected by many deeply incised drainageways. The soils are shallow loamy to clayey. The topography is steep and rough broken with slopes ranging from 40 to more than 70%. Between the drainageways, the ridges and crests are very narrow and knifelike. Many of the slopes are vertical or nearly vertical and barren of vegetation. Small areas of uplands having slopes of less than 40% and fans, footslopes, and narrow valleys with deep soils on slopes of less than 15% are included.

4F. This association consists of shallow to deep clayey soils on tops and sides of high narrow ridges and hills. Slopes are generally 15% to 40% for the shallow soils and less than 10% for the deep soils on fans and terraces.

4G. This association consists of moderately deep fine sandy loam, loamy and silty soils on the rolling to hilly dissected sedimentary uplands of the Fort Union and Hell Creek formations. Deep cut valleys flanked by steep sidewalls with sandstone outcrops and low ledges of shale and sandstone are separated by broad ridges up to 2 miles wide. Slopes range from 2% to 15%. Shallow

loamy and clayey soils over hard sandstone can be found, with slopes ranging from 7% to more than 35%.

GROUP 5 Moderately deep and shallow soils formed from consolidated sandstone or interbedded, hard sandstones and shales on nearly level to very steep sedimentary uplands. (labelled "Soils on hard sandstone or mixed sandstone and shale" on General Soils Map)

5A. This association is on a plateau that has been truncated and deeply dissected by streams, forming steep-sided valleys. It consists mainly of moderately deep clayey and loamy soils on the smooth, gently sloping or undulating (1 to 7% slopes). Shallow stoney and clayey soils over hard sandstone also occur, with slopes up to 60% on valley walls.

5B. This association is comprised of shallow loamy and clayey soils and moderately deep silty and loamy soils on rolling to very steep sandstone and siltstone uplands, on mainly Hell Creek and Fort Union formations. Large, thick masses of sandstone crop out, giving the appearance of giant stairsteps where three or four of these ledges occur. Slopes range from 8% to 20% for the moderately deep soils to 30% to 65% for the shallow soils. Rockland areas, consisting of barren outcrops of hard rock and siltstone with an admixture of soils of varying depths and texture, also occur.

5C. This association consists of shallow loamy and clayey soils on the deeply truncated and dissected sedimentary uplands, mainly of the Fort Union, Hell Creek, Judith River and Clagget formations. The topography is steep to very steep and rough broken with slopes of 30 to over 75%. Outcrops of sandstone and shale are common.

In some counties, particularly in the southern part of Rosebud, rounded hills or outcrops of scoria occur in this association.

5D. This association consists mainly of moderately deep clayey soils over hard sandstone or shale and shallow soils over hard sandstone on the undulating and rolling sedimentary uplands and plateaus. Slopes are predominantly less than 7%, with a few valleys flanked by sidewalls with slopes from 25% to over 60%.

GROUP 6 Moderately deep and shallow red-colored soils on the rolling, hilly and very steep scoria and porcelanite uplands. (labelled "Soils on scoria" on General Soils Map)

6A. This association consists mainly of shallow channery loam soils and moderately deep loamy soils underlain by scoria or porcellanite beds of the Fort Union formation and deep loamy soils in the swales and other areas of deposition accumulation. Slopes range from 4% to 10% for the moderately deep soils to over 40% for the shallow soils on valley sidewalls.

6B. This association consists of a mixed pattern of soils weathered from scoria and porcellanite and soils weathered from the weakly consolidated siltstones and loamstones of the Fort Union formation.

The soils weathered from scoria and porcellanite are shallow clayey and shallow to moderately deep loamy in texture on slopes ranging from 10 to 40%. Soils weathered from the Fort Union formation are moderately deep loamy and silty on slopes of 8 to 20%.

GROUP 7 Mountainous Lands (labelled "Mountainous land" on General Soils Map)

7A. Big Snowy Mountains

This association consists mainly of limestone rockland on very steep slopes.

Appendix C

METEOROLOGY

Air Quality

Air quality data are available at two locations in the study area, Colstrip and Billings (HES, 1974). The Colstrip data are being measured to determine the existing background air quality prior to the construction of coal fired electric generating units at Colstrip. These data can therefore be assumed to be fairly typical of the rural, undeveloped portions of the study area. Billings is the largest urban center in the study area.

Approximately four to five months of data are now available from Colstrip (HES, 1974). The average of 1,838 hourly readings of ozone ambient air concentrations for the period from December, 1973 to March, 1974 was .02 parts per million (ppm). The maximum ozone concentrations recorded were: 1 hour, .05 ppm; 3 hours, .05 ppm; and 24 hours, .04 ppm. The hourly ambient air concentrations of the oxides of nitrogen and sulfur dioxide for the period from December, 1973 to March, 1974,and from November, 1973 to March, 1974, respectively, were below the minimum detectable limits (.01 ppm for NO_x and .01 ppm for SO_2) of the techniques used to measure them. The geometric mean of suspended particulates at two Colstrip sites for the November, 1973 to February, 1974 period was 7 micrograms per cubic meter. These values are all less than applicable state and federal standards which are listed in Table C6.

Suspended particulate concentrations and sulfation rates were measured at various sites in Billings. Geometric means of

particulates ranged from a 12 month average ending in March of 1974 of 33 micrograms per cubic meter to a 12 month value of 70 micrograms per cubic meter. Monthly averaged sulfation rates at the various sites for the same 12 month period ranged from less than .01 to 2.9 milligrams per 100 square centimeters per day. Thus, at some sites in Billings the state and federal annual geometric particulate standard has been approached and the daily sulfation rate for a one month period has been exceeded.

Judging from the Colstrip and Billings sites, then, the air quality of the rural areas in the study area is probably significantly better than standards demand, while that in the Billings urban area may be approaching the limiting values as defined in the standards.

TABLE C1
ANNUAL CLIMATIC DATA
Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normal Period 1931-1960

STATION - ELEVATION		TEMPERATURE							PRECIPITATION			
		Mean	Max	Min	# of Days 90	# of Days 32	High	Low	Precip Mean	Snow Mean	# of Days 90	# of Days 32
Billings - 3567' 45 48'N 108 53'W	Record Year	47.5 N	58.7 26	35.7 26	29	153	106 26	-38 26	13.23 N	53.7	42	3
Busby - 3500 45 32'N 106 57'W	Record Year	44.3 N	59.4 54	28.2 54	39	208	109 55	-53 55	11.18 N	44.5	34	5
Colstrip - 3221' 45 53'N 106 36'W	Record Year	46.2 N	61.0 29	31.4 29	39	181	110 28	-50 28	15.13 N	45.8	37	6
Forsyth 2E - 3099' 46 16'N 106 37'W	Record Year	46.0	59.9 29	32.0 29	37	179	111 29	-46 32	12.17	31.1	33	3
Hardin - 2885' 45 45'N 107 36'W	Record Year	45.9	61.3 19	30.6 18	42	194	109 19	-42 19	12.01	33.3	31	3
Hysham - 2653' 46 18'N 107 13'W	Record Year	46.0	61.4 14	30.6 14	48	186	111 14	-48 13	11.32		31	3
Melstone - 2887' 46 36'N 107 52'N	Record Year	46.4 N	61.0 38	32.1 38	40	178	110 38	-51 38	11.90 N	34.6	34	5
Roundup - 3227' 46 28'N 108 34'W	Record Year	47.0 N	61.0 35	32.5 35	35	170	107 35	-52 35	10.93 N		32	4

N - indicates normal

TABLE C2

ANNUAL CLIMATIC DATA

Source: Climatography of the U.S. No. 60-24 - Climate of Montana, 1971

Base Period 1921-1950

STATION - ELEVATION		# of Days $\geq$.1"	# of Days $\geq$.5"	FREEZE DATA* Mean Date of Last Spring Occurrence 32^0	FREEZE DATA* Mean Date of First Fall Occurrence 32^0	Mean No. of Freeze Free Days
Billings - 3567' $45^0 48'N$ $108^0 53'W$	Report Year	42	3	5-15 29	9-24 30	132
Busby - 3500' $45^0 32'N$ $106^0 57'W$	Report Year	34	5	5-28 29	9-14 30	109
Colstrip - 3221' $45^0 53'N$ $106^0 36'W$	Report Year	37	6			
Forsyth 2E - 3099' $46^0 16'N$ $106^0 37'W$	Report Year	33	3	5-19 16	9-26 14	130
Hardin - 2885' $45^0 45'N$ $107^0 36'W$	Report Year	31	3			
Hysham - 2653' $46^0 18'N$ $107^0 13'W$	Report Year	31	3			
Melstone - 2887' $46^0 36'N$ $107^0 52'N$	Report Year	34	5	5-16 23	9-23 24	129
Roundup - 3227' $46^0 28'N$ $108^0 34'W$	Report Year	32	4	5-16 23	9-22 23	129 23

TABLE C3

TEMPERATURE

Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normals 1931-1960

		JANUARY							FEBRUARY							MARCH						
		Mean	Max	Min	# of Days		HIGH	LOW	Mean	Max	Min	# of Days		HIGH	LOW	Mean	Max	Min	# of Days		HIGH	LOW
					>90°	<32°						>90°	<32°						>90°	<32°		
Billings	Period	23.2	32.7	13.3	0	28	68	-30	25.7	35.9	15.8	0	25	69	-38	33.7	43.6	23.1	0	25	77	-19
	Years	N	26	26	10	10	26	26	N	26	26	10	10	26	26	N	26	26	10	10	26	26
Busby	Period	17.9	31.8	3.2	0	31	64	-52	21.7	35.8	6.6	0	28	69	-53	31.0	45.0	17.4	0	30	82	-37
	Years	N	54	54	10	10	55	55	N	54	54	10	9	55	55	N	54	54	10	9	55	55
Colstrip	Period	21.6	34.6	8.5	0	30	69	-40	24.5	37.5	11.8	0	27	70	-50	32.4	45.5	19.8	0	28	80	-28
	Years	N	29	29	10	10	28	28	N	29	29	10	10	28	28	N	29	29	10	10	28	28
Forsyth 2E	Period	17.5	29.8	5.1	0	31	68	-41	22.4	35.0	9.9	0	28	67	46	32.3	45.0	19.7	0	28	87	-26
	Years	33	29	29	10	10	29	32	33	29	29	10	10	29	32	33	29	29	10	10	29	32
Hardin	Period	19.3	33.1	5.3	0	31	68	-42	24.7	38.4	11.0	0	28	69	-38	32.7	46.2	19.1	0	29	80	-29
	Years	18	19	18	10	10	19	19	18	19	18	10	10	19	19	18	19	18	10	10	19	19
Hysham	Period	18.6	31.8	5.4	0	31	70	-48	23.8	37.5	10.2	0	27	70	-34	31.8	45.8	17.8	0	28	81	-29
	Years	15	14	14	10	10	14	13	15	14	14	10	10	14	13	15	14	14	10	10	14	13
Melstone	Period	21.5	33.1	7.8	0	30	70	-43	24.9	37.4	11.8	0	27	77	-51	33.0	46.4	20.9	0	27	78	-29
	Years	N	38	38	10	10	38	38	N	38	38	10	10	38	38	N	38	38	10	10	38	38
Roundup	Period	23.7	36.3	11.9	0	28	70	-41	26.5	38.8	13.5	0	26	75	-52	33.7	46.2	20.5	0	28	80	-33
	Years	N	35	35	10	10	35	35	N	35	35	10	10	35	35	N	35	35	10	10	35	35

N - normal value
+ - indicates occurance greater than 0 but less than 0.5 days.

TABLE C3

TEMPERATURE

Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normals 1931-1960

		APRIL							MAY							JUNE						
		Mean	Max	Min	# of Days >90°	# of Days <32°	HIGH	LOW	Mean	Max	Min	# of Days >90°	# of Days <32°	HIGH	LOW	Mean	Max	Min	# of Days >90°	# of Days <32°	HIGH	LOW
Billings	Period	46.0	57.5	33.9	0	16	92	-5	56.8	68.1	43.7	+	1	96	14	65.1	75.3	50.9	3	+	102	32
	Years	N	26	26	10	10	26	26	N	26	26	10	10	26	26	N	26	26	10	10	26	26
Busby	Period	44.0	58.9	29.1	0	20	89	-15	54.1	68.2	38.2	1	7	97	12	62.1	77.6	46.5	3	1	107	26
	Years	N	54	54	10	10	55	55	N	54	54	10	10	55	55	N	54	54	10	10	55	55
Colstrip	Period	44.8	59.4	30.2	0	20	90	-16	55.1	70.3	39.7	1	5	99	13	63.5	78.5	48.3	3	+	108	29
	Years	N	29	29	10	9	28	28	N	29	29	10	10	28	28	N	29	29	10	10	28	28
Forsyth 2E	Period	46.6	60.8	32.3	0	18	93	1	56.2	70.3	42.1	1	2	99	15	64.4	78.0	50.7	4	+	105	28
	Years	33	29	29	10	10	29	32	33	29	29	10	10	29	32	33	29	29	10	10	29	32
Hardin	Period	46.3	62.1	30.6	0	20	90	1	56.1	71.3	41.0	1	4	97	15	63.4	78.1	48.6	5	+	100	27
	Years	18	19	18	10	10	19	19	18	19	18	10	10	19	19	18	19	18	10	10	19	19
Hysham	Period	46.0	61.8	30.2	+	20	97	5	56.4	72.0	40.7	2	3	98	14	64.2	79.3	49.1	6	+	101	30
	Years	15	14	14	10	10	14	13	15	14	14	10	10	14	13	15	14	14	10	10	14	13
Melstone	Period	45.7	60.3	31.9	+	19	92	-15	56.2	70.3	41.0	1	4	97	8	64.0	78.1	49.8	3	0	108	32
	Years	N	38	38	10	10	38	38	N	38	38	10	10	38	38	N	38	38	10	10	38	38
Roundup	Period	45.7	59.8	31.3	0	18	89	-9	55.8	69.5	40.5	1	3	100	10	63.2	78.2	49.3	2	0	105	31
	Years	N	35	35	10	10	35	35	N	35	35	10	10	35	35	N	35	35	10	10	35	35

N - normal value
\+ - indicates occurance greater than 0 but less than 0.5 days.

TABLE C3

TEMPERATURE

Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana

Normals 1931-1960

		JULY							AUGUST							SEPTEMBER						
		Mean	Max	Min	# of Days $\geq 90^0$	# of Days $\leq 32^0$	HIGH	LOW	Mean	Max	Min	# of Days $\geq 90^0$	# of Days $\leq 32^0$	HIGH	LOW	Mean	Max	Min	# of Days $\geq 90^0$	# of Days $\leq 32^0$	HIGH	LOW
Billings	Period	74.7	87.4	58.6	14	0	106	42	71.9	85.1	56.5	10	0	104	40	60.4	73.8	47.3	2	1	100	26
	Years	30	26	26	10	10	26	26	30	26	26	10	10	26	26	30	26	26	10	10	26	26
Busby	Period	71.0	88.4	51.9	17	0	109	30	68.9	86.9	49.5	14	0	107	26	58.0	75.4	39.8	4	7	105	6
	Years	30	54	54	9	10	55	55	30	54	54	9	10	55	55	30	54	54	10	9	55	55
Colstrip	Period	72.6	90.2	54.9	17	0	110	34	70.5	88.5	52.9	14	0	107	34	59.8	77.1	42.6	4	3	102	18
	Years	30	29	29	10	10	28	28	30	29	29	10	10	28	28	30	29	29	10	9	28	28
Forsyth	Period	73.1	89.0	57.1	16	0	111	38	71.3	87.9	54.6	13	0	108	29	60.5	76.2	44.8	3	1	103	22
	Years	33	29	29	10	10	29	32	33	29	29	10	10	29	32	33	29	29	10	10	29	32
Hardin	Period	71.8	89.7	53.9	18	0	107	33	70.0	88.1	51.8	15	0	109	34	59.2	76.3	42.0	3	4	104	24
	Years	18	19	18	10	10	19	19	18	19	18	10	10	19	19	18	19	18	10	10	19	19
Hysham	Period	72.8	90.5	55.0	19	0	111	38	70.7	89.3	52.1	17	0	108	35	59.8	77.5	42.0	4	3	102	21
	Years	15	14	14	10	10	14	14	14	14	14	9	9	14	14	15	14	14	10	10	14	13
Melstone	Period	73.0	89.5	55.8	18	0	108	35	70.3	88.0	52.7	14	0	110	34	60.1	76.8	42.8	4	2	106	20
	Years	30	38	38	10	10	38	38	30	38	38	8	10	38	38	30	38	38	10	10	38	38
Roundup	Period	72.1	88.7	55.1	16	0	107	36	69.8	87.3	52.6	13	0	106	32	59.6	76.0	43.0	3	2	102	22
	Years	30	35	35	10	10	35	36	30	35	35	10	10	35	35	30	35	35	10	10	35	35

N - normal value

+ - indicates occurance greater than 0 but less than 0.5 days.

TABLE C3

TEMPERATURE

Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana

Normals 1931-1960

		OCTOBER							NOVEMBER							DECEMBER						
		Mean	Max	Min	# of Days $\geq 90^0$	# of Days $\leq 32^0$	HIGH	LOW	Mean	Max	Min	# of Days $\geq 90^0$	# of Days $\leq 32^0$	HIGH	LOW	Mean	Max	Min	# of Days $\geq 90^0$	# of Days $\leq 32^0$	HIGH	LOW
Billings	Period	49.5	61.8	38.1	0	9	86	4	35.1	45.2	26.3	0	21	71	-22	28.4	38.5	20.3	0	27	69	-17
	Years	30	26	26	10	10	26	26	30	26	26	10	10	26	26	30	26	10	10	10	26	26
Busby	Period	46.9	62.4	29.6	+	24	92	-25	32.3	46.6	18.5	0	29	78	-38	23.7	36.0	8.4	0	31	76	-50
	Years	30	54	54	10	7	55	55	30	54	54	10	9	55	55	30	54	54	10	10	55	55
Colstrip	Period	48.6	64.6	32.6	+	15	90	4	34.4	47.2	21.3	0	24	74	-32	26.8	39.1	14.2	0	29	74	-30
	Years	30	29	29	10	7	28	28	30	29	29	10	7	28	28	30	29	29	10	10	28	28
Forsyth	Period	48.6	63.7	33.5	+	16	93	-2	34.1	46.7	21.5	0	26	78	-26	24.7	36.9	12.6	0	29	73	-43
	Years	29	29	29	9	6	29	32	33	29	29	10	10	29	32	33	33	29	10	10	29	32
Hardin	Period	48.2	65.0	31.3	+	19	92	6	34.0	47.7	20.3	0	28	76	-31	25.5	39.2	11.8	0	31	71	-30
	Years	17	19	18	10	9	19	19	18	19	18	10	10	19	19	18	19	18	10	10	19	19
Hysham	Period	48.4	65.2	31.6	+	18	91	9	33.6	47.2	20.1	0	27	75	-28	25.9	38.9	13.0	0	29	65	-36
	Years	15	14	14	0	0	14	13	14	14	14	9	9	14	13	15	14	14	10	10	14	13
Melstone	Period	49.0	64.1	32.9	+	15	94	5	35.2	49.1	22.6	0	25	80	-30	27.5	38.7	14.6	0	29	71	-32
	Years	30	38	38	10	10	38	38	30	38	38	10	10	38	38	30	38	38	10	10	38	38
Roundup	Period	49.2	63.6	33.7	0	14	95	-10	36.1	48.7	23.0	0	24	78	-36	29.0	39.1	15.6	0	27	69	-43
		30	35	35	10	10	35	35	30	35	35	10	10	35	35	30	35	35	10	10	35	35

N - normal value

+ - indicates occurance greater than 0 but less than 0.5 days.

TABLE C4

PRECIPITATION
Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normal Period 1931-1960

		JANUARY				FEBRUARY				MARCH			
		Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	<.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"
Billings	Period Year	.54 N	7.4 26	3 7	0 10	.60 N	9.7 26	3 7	+ 10	1.05 N	10.2 26	4 7	+ 10
Broadview	Period Year	.55 9		2 7	+ 9	.60 8		2 5	+ 7	.91 8		3 5	+ 7
Busby	Period Year	.36 N	7.9 55	1 6	0 9	.33 N	5.5 55	1 7	+ 10	.62 N	7.5 55	2 7	0 10
Colstrip	Period Year	.58 N	6.5 26	1 7	0 10	.60 N	6.8 26	2 7	0 10	1.00 N	9.3 26	2 7	+ 10
Forsyth 2E	Period Year	.41 37	6.1 32	1 7	0 10	.37 36	5.6 32	1 7	0 10	.59 36	5.9 31	2 7	+ 10
Hardin	Period Year	.46 19	6.6 14	1 7	0 10	.41 19	4.6 14	2 7	0 10	.65 19	6.8 14	2 7	0 10
Hysham	Period Year	.33 15		1 7	0 9	.44 15		1 6	+ 10	.74 15		2 7	+ 10
Melstone	Period Year	.43 N	6.4 36	2 7	0 10	.40 N	5.3 35	2 7	+ 10	.64 N	6.7 35	1 7	+ 10
Roundup	Period Year	.29 N		1 7	0 10	.32 N		1 7	0 10	.56 N		2 7	0 10

+ - indicates occurance greater than 0 but less than .5 days
N - indicates normal

TABLE C4

PRECIPITATION
Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normal Period 1931-1960

		APRIL				MAY				JUNE			
		Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"
Billings	Period	1.31	7.2	5	1	1.88	1.2	6	1	2.55	0.1	6	1
	Year	N	26	7	10	N	26	7	10	N	26	7	10
Broadview	Period	1.85		4	1	2.76		5	2	2.11		6	1
	Year	9		7	9	8		6	8	8		6	8
Busby	Period	1.15	4.7	4	+	1.99	2.0	6	1	2.42	0.2	6	1
	Year	N	55	7	10	N	55	7	10	N	55	7	10
Colstrip	Period	1.64	6.4	5	1	2.26	0.3	6	1	2.94	0.4	6	2
	Year	N	26	7	10	N	28	7	10	N	29	7	10
Forsyth 2E	Period	.88	2.8	5	+	2.13	0.4	5	1	2.86	0.1	6	1
	Year	35	32	7	10	34	32	7	10	33	32	7	10
Hardin	Period	1.10	2.9	3	+	1.65	0.3	4	1	2.74	0.1	6	1
	Year	19	14	7	10	20	18	7	10	20	19	7	10
Hysham	Period	1.03		4	1	1.66		4	1	2.49		6	1
	Year	15		6	9	15		7	10	15		7	8
Melstone	Period	.88	3.0	3	1	1.74	0.7	5	1	2.93	T	7	2
	Year	N	33	6	10	N	38	6	10	N	39	7	10
Roundup	Period	.75		3	+	1.80		5	2	2.53		7	1
	Year	N		7	10	N		7	10	N		7	10

+ - indicates occurance greater than 0 but less than .5 days
N - indicates normal

TABLE C4

PRECIPITATION
Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normal Period 1931-1960

		JULY				AUGUST				SEPTEMBER			
		Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"
Billings	Period Year	.90 N	T 26	2 7	+ 10	.90 N	T 26	3 7	+ 10	1.19 N	.6 26	2 7	+ 10
Broadview	Period Year	.59 8		2 6	+ 8	1.32 9		4 7	1 9	.65 8		2 6	1 8
Busby	Period Year	1.07 N	T 55	2 7	1 10	1.10 N	T 55	3 7	1 10	1.08 N	.8 55	2 7	1 10
Colstrip	Period Year	1.23 N	T 29	2 7	1 10	1.22 N	T 29	4 7	1 10	1.19 N	.9 29	2 7	+ 10
Forsyth 2E	Period Year	1.32 32	.1 32	3 7	+ 10	.89 33	T 32	3 7	1 10	1.04 33	T 32	2 6	+ 9
Hardin	Period Year	.86 20	T 19	2 7	1 10	.99 20	T 19	3 7	+ 10	1.29 20	.5 19	2 7	+ 10
Hysham	Period Year	.98 15		2 7	+ 10	.99 15		4 5	+ 9	.84 15		2 7	+ 10
Melstone	Period Year	1.22 N	T 39	3 7	+ 10	.94 N	T 39	3 6	1 10	.89 N	.2 39	2 7	+ 10
Roundup	Period Year	1.21 N		4 7	+ 10	.97 N		3 7	1 10	.96 N		2 7	+ 10

+ - indicates occurance greater than 0 but less than .5 days
N - indicates normal
T - indicates trace element

TABLE C4

PRECIPITATION

Source: Climatic Summary of the U.S. - Supplement for 1951-1960 - Montana
Normal Period 1931-1960

		OCTOBER				NOVEMBER				DECEMBER			
		Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"	Precip Mean	Snow Mean	Precip # of Days ≥.1"	≤.5"
Billings	Period	1.09	3.1	3	+	.63	6.2	2	+	.59	8.0	2	0
	Year	N	26	7	10	N	26	7	10	N	26	7	10
Broadview	Period	.99		2	1	.79		3	+	.42		1	+
	Year	9		6	9	10		7	10	9		6	9
Busby	Period	.90	3.6	2	+	.57	5.3	3	+	.44	7.0	2	0
	Year	N	55	6	9	N	55	7	10	N	54	6	9
Colstrip	Period	1.22	3.1	2	+	.66	5.3	3	+	.59	6.8	2	+
	Year	N	28	7	9	N	28	7	10	N	29	7	10
Forsyth 2E	Period	.86	1.2	2	+	.50	4.1	2	+	.32	4.8	1	+
	Year	33	30	3	8	34	32	7	10	34	32	7	10
Hardin	Period	.80	1.1	2	+	.55	2.5	2	+	.51	7.9	2	0
	Year	20	17	7	10	20	15	7	10	20	12	7	10
Hysham	Period	.88		2	+	.52		2	+	.42		1	+
	Year	15		7	10	15		6	10	16		7	9
Melstone	Period	.87	1.9	3	+	.47	3.7	2	+	.49	6.7	1	+
	Year	N	37	6	9	N	37	7	10	N	37	7	10
Roundup	Period	.82		2	+	.36		1	+	.36		1	+
	Year	N		7	10	N		7	10	N		7	10

+ - indicates occurance greater than 0 but less than .5 days
N - indicates normal

TABLE C5

BILLINGS CLIMATIC DATA

	Length of Record (Years)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Max. 24-hr Precip.	38	1.41	0.61	0.97	2.48	2.83	2.78	1.87	2.47	2.19	1.98	1.37	0.71	2.83
Year		1972	1952	1946	1955	1952	1937	1958	1965	1966	1937	1959	1955	May 1952
Max. 24-hr Snowfall	34	16.6	9.0	10.5	23.7	5.7	2.0	0.0	0.0	6.3	10.0	15.3	13.0	23.7
Year		1972	1944	1964	1955	1967	1950			1962	1949	1959	1955	April 1955
Mean Relative Humidity														
05	13	65	67	68	70	71	74	64	59	67	63	67	66	67
11	13	61	59	53	50	49	49	39	39	50	49	58	61	52
17	13	58	54	46	42	43	43	31	29	40	42	54	58	45
23	13	64	64	62	61	61	62	50	45	57	56	62	64	59
Wind														
Mean Speed	33	13.0	12.4	11.6	11.8	11.1	10.4	9.8	9.6	10.4	11.2	12.2	13.0	11.4
Prevailing Direction	15	SW	SW	SW	SW	NE	SW	SW	SW	SW	SW	SW	WSW	SW
Fastest Mi. Mean Speed	29	66	72	61	72	68	79	73	66	61	68	63	66	79
Fastest Mile Direction	29	W	W	NW	NW		NW	N	NW	NW	NW	NW	NW	NW
Fastest Mile Year		1953	1963	1956	1947	1939	1968	1947	1947	1949	1949	1948	1953	June 1968
Mean Number of Days of														
Thunderstorms	33	0	+	+	1	4	8	8	6	2	+	0	+	30
Heavy Fog	25	1	2	2	3	1	1	+	+	1	2	2	2	19
Snowfall Exceeding 1"	30	3	3	3	2	+	+	0	0	+	1	2	3	19

TABLE C6

State and Federal Air Quality Standards

Pollutant	Time Period	Montana	Federal Standards, ug/m3 Primary	Secondary
Oxidant	1 hour	160[a] ug/m3 (micrograms/cubic meter	160[a]	160[a]
Nitrogen Oxides	annual	100[a] ug/m3	100	100
SO^2	1 hour	0.25 ppm[b] (650 ug-m3)	none	none
	3 hour	none	none	1300[a]
	24 hour	0.10 ppm (260 ug-m3)	365[a]	365[a]
	annual	0.02 ppm (60 ug-m3)	80	60
Sulfation	1 month	0.50 mg/(100cm2-day)	none	none
	annual	0.25 mg/(100cm2-day)		
Particulate Matter	24 hour	200 ug/m3[c]	260[a]	150[a]
	annual	75[d]	75[d]	60[d]
Dust fall	3 months	15 ton/mile2/month[e]	none	none
	3 months	30ton/mile2/month[f]	none	none

a Not to be exceeded more than once per year

b Not to be exceeded more than one hour in any four consecutive days

c Not to be exceeded more than 1 percent of days a year

d Geometric mean

e Residential areas

f Heavy industrial areas

TABLE D

HYDROLOGY

FLOW VALUES (in CFS) FOR SELECTED STREAMS WHICH TRAVERSE STUDY AREA

Stream and Location	Average Annual Flow	Maximum Flow	Minimum Flow	Average June	Average Sept.	Average Jan.	Yrs of Record
Little Bighorn River							
Wyola, Mont.	150	2730	21	535	103	63	33
Hardin, Mont.	285	4520	0.20	911	128	119	19
Bighorn River							
St. Xavier, Mont. (flow controlled by Yellowtail dam)	3550	37400	112				38
Bighorn, Mont.	3851	26200		8588	2791	2767	27
Yellowstone River							
Billings, Mont.	6858	66100	430				44
Miles City	11330	96300	996	14794	7043	4815	45
Clarks Fork							
Belfry, Mont.	947	10900	32				51
Edgar, Mont.	1044	10900	36				48
Pryor Creek							
Billings, Mont.	50	1700	0				15
Musselshell River							
Rygate	168	9500	0				26
Roundup	202	9610	0.60				26
Musselshell	191	9850	0				29
Rosebud Creek							
Forsyth	24	596	0	40	6.0	4.0	6
Tongue River							
Decker, Mont.	493	7480	3.9				12
Miles City,	423	13300	0	628	178	161	29

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C
Roundup
C
Forsyth
D
D
A
E
F
A
F
B
B
Billings
Lame Deer
A
MPC Preferred Corridor
B,C,D,E
Alternate Corridors
F
EPD Preliminary Corridor